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TEXTILE
BLEACHING

“ MATHER ” KIERS IN BLEACH HOUSE

Frontispiece

PITMAN'S COMMON COMMODITIES
AND INDUSTRIES

TEXTILE BLEACHING

BY

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PREFACE

In this little book I have attempted to give the non-technical reader a brief account of the development and present day methods of one of our oldest industries. Textile bleaching, in its widest sense, is so intimately connected with the great textile trade of this country that it may be well called a *key industry*, but, fortunately for us, it is one which is practically independent of foreign countries for the materials it uses.

The word bleaching is used in different senses in connection with the animal and vegetable fibres respectively. In the case of the animal fibres the term usually refers only to the actual destruction or removal of the natural colour of the material, whilst, in the case of cotton and the other vegetable fibres, the meaning of the term is enlarged to include all the preliminary cleansing operations through which the material has to pass besides the actual destruction of the colour. In order to make the book more complete I have used the term in its larger sense when dealing with the animal fibres also, although, in practice, the preliminary cleansing operations are usually included under the head of *Scouring*.

It is with some hesitation that I have included the chapter on the chemicals employed, but I have come to the conclusion that, although this book is primarily written for the non-technical reader, yet the latter will, in most cases, find this chapter of assistance in understanding the actual bleaching operations.

In dealing with an industry handling such a countless variety of materials, it is of course quite impossible to describe all the methods in use, and the whole plan of this book is to deal with the main processes only.

Written, as it has been, for non-technical readers, this little book has of course no pretensions to be a scientific treatise on the subject, and I have avoided, so far as possible, any statements which would presuppose a knowledge of chemistry on the part of the reader. This method of treatment entails, of course, a certain loss of scientific exactness in some of the explanations given, but I trust that, nevertheless, it will serve the purpose for which it is intended.

Owing to limitations of space it has only been possible to mention typical examples of the various machines employed, and the fact that many well-known makes are not mentioned must not be taken as any reflection on their quality.

In conclusion, I desire to express my best thanks to Messrs. Sir James Farmer & Sons, Ltd., Salford; Archibald Edmeston & Sons, Ltd., Patricroft; Wm. Whiteley & Sons, Ltd., Huddersfield; Mather & Platt, Ltd., Manchester; and Petrie & McNaught, Ltd., Rochdale, who have kindly supplied me with illustrations of certain of their machines.

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THE ROYAL TECHNICAL COLLEGE,
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TEXTILE BLEACHING

CHAPTER I

THE TEXTILE FIBRES

Introduction. The industry known as bleaching is of very ancient origin. The actual date of its introduction is lost in the mists of antiquity, but it probably had its primitive beginnings about the period when mankind replaced the animal skins which he had previously worn by woollen and other fabrics.

The word *bleaching* itself appears to be derived from the Anglo-Saxon *blǣcan: to become pale,* and is closely connected with such words as *blanch,* meaning to whiten, and *bleak,* meaning bare, and it is interesting to note that many of the foreign equivalents appear to have been derived from the same original source, as is shown by their spelling: thus the French for *to bleach* is *blanchir,* whilst the German equivalent is *bleichen.*

All these words really mean " to whiten " and for many centuries the bleacher was known in this country as a " whitster."

The word *textile* really means woven, being derived from the Latin *texo: I weave,* but in course of time the term has been extended to cover the materials used in weaving, so that, at present, " textile bleaching " includes the bleaching, in all stages of its manufacture, of any fibrous material which can be spun into yarn or woven into cloth.

The fibres mentioned are of the most varied character and in order to understand properly the methods employed in bleaching them a general knowledge of the main properties of the more important ones is desirable.

THE TEXTILE FIBRES

The textile fibres of commerce can be divided into four main classes—

1. Vegetable,
2. Animal,
3. Artificial,
4. Mineral.

Practically the only mineral fibre of any importance is Asbestos, which is found in a more or less fibrous condition, and can be woven into special materials where heat and fire resisting properties are essential; but neither this nor the metallic fibres (or wires), which may also be called artificial fibres, have any interest to the bleacher, so that they will not be dealt with further.

The only important artificial fibre in the true sense of the word is *Artificial Silk*, and as all the artificial silks of any importance are prepared from vegetable substances, the textile fibres might really be classified, so far at least as the bleacher is concerned, into the two classes, vegetable and animal.

THE VEGETABLE FIBRES

These, as their name indicates, are all products of the vegetable kingdom. They are obtained from very different parts of the plant. Cotton, which is by far the most important, is a *seed-hair* growing on the seeds of the cotton plant which it surrounds with a ball of fluff, probably intended to aid in the distribution of the seeds by the wind as in the case of thistle-down.

The fruit of the cotton plant is divided into from three to five sections, each of which contains a number of seeds, and when it is ripe this pod bursts open disclosing a mass of fibres.

Each cotton fibre consists of a single cell or tube, pointed and closed at one end and open at the other, where it was attached to the seed. In the quite ripe condition the fibre has the appearance, under the microscope, of a flattened tube or ribbon, which usually has a characteristic corkscrew twist and averages from one to one-and-a-half inches in length, and about one fifteen-hundredth of an inch in diameter.

When purified from traces of impurities the cotton fibre consists of a substance known as *cellulose*. This, when quite pure, is a white substance which is very closely allied chemically to such substances as starch, sugar, dextrine, etc. Like them it contains carbon, hydrogen and oxygen and belongs to the class of substances known as *carbohydrates*.

Cellulose is insoluble in water and all ordinary solvents but can be dissolved by some special ones, a fact which is made use of in the manufacture of artificial silk.

Linen. The vegetable fibre next in importance to cotton is flax or linen. This has quite a different origin to the cotton fibre, being found in the stem of the flax plant, to which it gives strength and rigidity. It comes into the market as fibrous strands two or more feet in length, which really consist of a great number of individual flax fibres tightly stuck together by means of a gummy binding material. If these ultimate fibres be examined they will be found to consist of single tube-like vegetable cells pointed at each end and about the same size as cotton fibres.

Like cotton, the linen fibre consists, when purified, of cellulose, but, in the raw material, the amount of impurity is much greater than is the case with cotton.

Many other vegetable fibres are used for textile purposes in different parts of the world but the only ones much employed in this country are *Hemp*, *Jute*, and *Ramie* or *China Grass*.

These, like linen, are all *bast* fibres and obtained from the stalks of various plants. They consist essentially of cellulose, with the exception of jute, which contains a compound cellulose more like wood in composition. Hemp and jute come into the market in the form of long strands consisting of great numbers of individual fibres stuck together, whilst ramie or china grass can be obtained as very long single cells.

Action of Chemicals upon the Vegetable Fibres. As the various operations employed in bleaching the textile fibres consist mainly of successive treatments with different chemicals it is naturally of the greatest importance that the chemicals employed should effect the desired results without injuring the fibres themselves.

For a full account of the chemical properties of the fibres the reader is referred to the special books on the subject, but it may be stated here that, speaking quite generally, the vegetable fibres show the following behaviour when treated with chemicals—

1. They are not injured by treatment with solutions of alkalies such as lime, soda, soap, etc., under ordinary conditions.

2. They are very easily injured by mineral acids, e.g. sulphuric or hydrochloric, unless special precautions are taken.

Dilute mineral acids, that is to say, mineral acids mixed with a large proportion of water, have little or no injurious action if used cold, but if the weak acid be allowed to dry on the fibre without previous washing with water, the acid will become stronger owing to the evaporation of the water and will finally become so strong that it will attack or *tender* the material, especially if heat be applied.

As weak acids are repeatedly employed in bleaching, it is of the greatest importance that they should be thoroughly removed before the material is dried in order to avoid risk of injury to the latter.

ANIMAL FIBRES

These may be divided into two classes—

1. The wool or hair of various animals, e.g. the sheep, horse, cow, camel, or goats of various species.
2. Silks of various kinds.

WOOL AND HAIR

These fibres are quite different in their structure from the vegetable fibres. Whilst the latter consist of tube-like cells, either simple in their structure as with cotton, or of a more compound character as with the other vegetable fibres, the wool and hair fibres are of a very complicated structure and consist of a great number of animal cells of very irregular shapes which cannot be separated from one another without destroying the fibre.

Wool and hair are really only modifications of the same outgrowths from the skin. The fibres vary very much in structure not only when obtained from different animals but even when growing on different parts of the same animal, so that it is often possible to obtain from one animal fibres varying from a fine soft fibre like merino wool to a coarse stiff one similar to a bristle.

Whilst the basis of all the vegetable fibres is the substance called cellulose, the wool and hair fibres consist essentially of a very complicated substance known as *Keratine*, which is closely connected in chemical constitution with horn, finger-nails and other outgrowths from the skin. It contains the elements carbon, hydrogen, oxygen, nitrogen and sulphur.

SILK

Silk differs entirely in structure from all the other textile fibres. Whilst the others are all cellular in structure, the various silks have no organised structure at all but are in reality simply solidified liquids.

The silk liquid is secreted by special glands in the silkworm and excreted by the worm through orifices in its head. As the thick viscous fluid emerges, the worm moves its head from side to side, so that the sticky liquid adheres to any object touched by the worm's head and forms a network of filaments similar to those which hang from a spoon which has been lifted out of a thick liquid such as treacle. On exposure to the air this liquid almost immediately solidifies and the network of fibres thus formed constitutes the cocoon of the silkworm, from which the silk is obtained by softening the cocoons in warm water and winding off the silk thread which may be hundreds of yards in length.

The opening in the head of the worm through which the silk fluid emerges is supplied by two fine ducts or tubes, so that the thread is really formed by two streams of the liquid sticking together. Examination of the fibre as spun by the worm shows that it really consists of two real fibres composed of a substance known as *Fibroine* which are surrounded and stuck together by a layer of a gummy substance called *Sericine* or *Silk-gum*. These two substances are very similar in chemical composition, but the silk-gum is soluble in solutions of soap or of weak alkalies which do not affect the real silk fibres.

Silk contains the same chemical elements as wool with the exception of sulphur.

Action of Chemicals upon Animal Fibres. The animal fibres differ very materially from the vegetable fibres in their behaviour towards chemicals.

Whilst the vegetable fibres are, speaking generally, not injuriously affected by alkalies but sensitive to acids, the animal fibres, on the other hand, are very easily injured by alkalies but can stand the action of acids of moderate strength even at the boiling temperature.

As most of the chemicals employed in bleaching are either of an acid or alkaline character it follows that the two different kinds of fibres must need very different treatment in order to bleach them without injury.

ARTIFICIAL SILKS

These are all made artificially by a process very similar to the production of natural silk by the worm.

A solution of cellulose or of some cellulose product is dissolved in a suitable solvent and the thick viscous solution thus obtained is forced, under pressure, through a fine orifice, so that the liquid issues as a very fine thread which is coagulated to a solid fibre by chemical treatment or other means. The further processes depend on the particular variety of artificial silk being made, but the final product is practically a pure cellulose fibre which has similar chemical properties to cotton but requires very careful handling when wet owing to its loss of strength in that condition.

CHAPTER II

THE CHEMICALS EMPLOYED IN BLEACHING

A FULL description of the various chemicals employed in bleaching would be quite out of place in a book of this character, but, nevertheless, a short account of the more important of them may prove of considerable assistance to the non-technical reader in giving him some idea of the general principles underlying the various bleaching operations.

For practical purposes the chemicals employed can be divided roughly into five main classes, namely—

1. Acid substances, e.g. sulphuric acid.
2. Alkaline substances, e.g. ammonia, soda, lime, etc.
3. Bleaching substances, in the strict sense of the word, e.g. bleaching powder, peroxide of hydrogen.
4. Emulsifying bodies, e.g. soaps of various kinds.
5. Solvents for fats and oils, e.g. benzine and petrol.

The more important of these chemicals will be dealt with in the above order.

ACIDS

The use of acids in bleaching depends mainly on the power they possess of dissolving and removing mineral matter, such as lime, which may either be present in the material as it reaches the bleacher or else applied to it by the bleacher himself in an earlier stage of the process. The only acids used on a large scale for this purpose are sulphuric acid and hydrochloric acid.

Sulphuric Acid. This is manufactured on an enormous scale either by the old Chamber process or by one of the newer " Contact " processes. All these methods consist essentially in the preparation of sulphur dioxide by the oxidation of sulphur or of some sulphur-containing material and the conversion of this product into sulphuric acid by further oxidation and combination with water. In the pure state it is a colourless, oily, very corrosive liquid which is nearly twice as heavy as water. The ordinary commercial acid is known as *oil of vitriol* and is sold in various strengths. For use in bleaching it must be largely diluted with water as the strong acid would destroy the material. Great care must be taken when mixing water with the strong acid as the mixture becomes very hot. The acid should be run into the water in a thin stream with constant stirring, and on no account should the water be poured into the acid as the heat evolved may cause dangerous spurting. Its chief use in bleaching is in the so-called *souring* operations which are employed to remove lime and other mineral matters from the fibres, the acid being able to convert many mineral substances into bodies called *sulphates*, most of which are soluble in water, so that they can be removed from the material by subsequent washing with water.

The ordinary dilute acid attacks most metals and in practice it is better to employ wooden or stoneware vessels, or else to line the tanks used for the *souring* with sheet lead, which is very little affected by the acid.

Hydrochloric Acid. This acid, which is also known by its old names of Muriatic acid or Spirits of Salt, has, until recently, been produced as a by-product in the manufacture of carbonate of soda by the Leblanc process, being produced by the action of sulphuric acid upon common salt. It is largely due to this fact that the Leblanc method has been able to hold its own so long against the competition of improved processes. Hydrochloric acid is really a gas under ordinary conditions but it is extremely soluble in water and comes into commerce as a solution in the latter. This solution is colourless when quite pure but the commercial product is usually yellow from the presence of iron as an impurity. It usually contains about 30 per cent of its weight of pure hydrochloric acid.

It is used in bleaching for the same purposes as sulphuric acid, and is preferred to the latter if it is required to remove lime from the material owing to the fact that the compound of hydrochloric acid with lime is much more soluble in water than the sulphate of lime produced when sulphuric acid is employed.

For use with vegetable fibres the commercial acids are diluted with from 25 to 100 times their volume of water, and great care must be taken to thoroughly wash out any acid from the material before drying the latter, in order to prevent tendering.

The other acids are very little used in bleaching. Nitric acid is sometimes employed in silk bleaching and oxalic acid is used for the removal of iron mould from textile materials owing to its solvent power for the oxide of iron.

ALKALIES

The main use of alkaline substances in bleaching is for the decomposition and removal of oily, waxy and gummy impurities in the preliminary cleansing operations. Their action on oily and fatty matters will be explained when dealing with soaps.

They are also employed in some cases to neutralize any acid which may have been left in the material and which would be liable to injure the latter. A third important use for these substances is in the softening of water.

Lime. This substance, which is also called calcium oxide or quick lime, is the well known white product obtained when limestone is heated in kilns. If a little water be poured on to the lumps of quick lime the latter soon begins to combine with it chemically, becoming very hot and giving off clouds of steam. The water converts the calcium oxide or quick lime into calcium hydroxide or slaked lime and the lumps break down into a fine powder. This slaked lime is very slightly soluble in water (lime water) and, in practice, it is more usual to employ it in the form known as milk of lime, which is simply lime water containing a considerable amount of undissolved hydroxide in suspension.

Lime is the cheapest alkali and is largely used in bleaching vegetable fibres, softening water and in the manufacture of bleaching powder.

Carbonate of Soda. This is manufactured from common salt by various processes. It comes into the market in different degrees of purity. *Pure alkali* is a white powder consisting of almost pure carbonate, whilst *washing soda* or *soda crystals* contain about 60 per cent of their weight of water combined with the carbonate in a crystalline form. For bleaching purposes on the large scale it is often used in a cheaper, less pure form known as *soda ash.* It is largely used in the cleansing of both animal and vegetable fibres and also in the softening of water.

Carbonate of Potash was in former days very largely employed, being obtained, in an impure form, from wood ashes, but it has been to a great extent replaced for most purposes by the much cheaper soda salt which has practically the same action.

Caustic Soda, or sodium hydroxide, comes into the market either as a white solid or else as a very strong solution in water. It can be prepared from carbonate of soda by boiling a solution of the latter with lime.

The calcium hydroxide decomposes the carbonate of soda, forming carbonate of lime (chalk), which is nearly insoluble in water and sinks to the bottom of the vessel leaving a clear solution of sodium hydroxide which can either be used in that form or else evaporated in order to obtain the solid product.

Of recent years this method for preparing caustic soda from the carbonate has been largely replaced by an electrical process which prepares the caustic directly from common salt, thus dispensing with the intermediate production of the carbonate.

In this process a current of electricity is passed through a cooled solution of common salt (sodium chloride) ; the current splits up the salt into its components: chlorine, which comes off as a gas and is collected separately, and the metal sodium which is at once acted upon by the water, forming sodium hydroxide and hydrogen gas.

Caustic soda is largely used in the cleansing of vegetable fibres as it has the power of saponifying (see below) the oily and waxy impurities present, converting them into soluble soaps which can then be easily removed by washing with water. It is very largely employed in soap manufacture and also in softening water.

Owing to its injurious action on wool it must not be used with that fibre.

Among the less important alkalies, *ammonia, borax* and *silicate of soda* or *water glass* are used to some extent for similar purposes.

BLEACHING CHEMICALS PROPER

The acids and alkalies mentioned above are very largely employed in the bleaching of textile materials but their action is not really a bleaching one in the strict sense of the word, but is more of a preparatory cleansing character resulting in the removal of greasy and other impurities with which the materials are impregnated, thus rendering them more permeable to liquids.

After passing through these preliminary cleansing operations, the material, although clean, is usually not white in colour, as it still contains, in most cases, the natural colouring matters originally present in the fibre, which are not much affected by the cleansing. If the material is to be dyed in dark shades or black, this remaining colour is usually of no account, but if it is to be left white or dyed in pale bright colours, this natural tint must be counteracted or removed in some manner.

If it has only a faint yellowish tint and is wanted white, it is frequently sufficient to simply hide the yellow tint by *blueing* the material with some blue pigment or dye, e.g. ultramarine, which will counteract the yellow tint and give an apparent white. This is what is done by the use of the *blue-bag* in ordinary domestic washing. To obtain a satisfactory white, however, it is usually necessary to convert the colouring matter present into a colourless substance by treatment with suitable chemicals, which may thus be termed bleaching agents proper as distinguished from those which have mainly a cleansing action.

The chemicals employed for this purpose may be divided into two main classes—

1. Those which destroy the residual colour by means of their oxidising action.

2. Those which convert the colouring matters present into colourless substances by what is termed reduction.

The first class of substances usually give the most permanent results as the colouring matters are actually destroyed whilst the reducing bleaches, although giving good results at the time, do not totally destroy the colour, so that, after a time, it gradually returns again owing to the influence of the air, washing, etc.

Oxidising Bleaches. As will be seen later on, the oldest method of bleaching was by exposure of the material to the action of sunlight and air, usually in the presence of moisture. This is a very slow process and largely dependent on the weather and, at the present day, the most important oxidising bleach employed is the well-known substance called *bleaching powder* or *chloride of lime.* This is used in enormous quantities for bleaching vegetable fibres but cannot be employed for animal ones as it has a very destructive action upon them.

Bleaching powder is manufactured by passing chlorine gas into large chambers containing slaked lime spread out in shallow layers. The lime absorbs the chlorine, forming bleaching powder, which is then removed and packed into barrels for the market. It is a white powder with the well known characteristic smell and appears to owe its bleaching properties to the fact that its solution in water contains the substance known as *hypochlorite of lime.* A corresponding *hypochlorite of soda* can be obtained from bleaching powder solution by the addition of soda ash, which precipitates the lime as an insoluble carbonate leaving a clear solution containing the soda compound. This has similar bleaching properties to the lime one and, although it is more expensive, is sometimes used in place of the latter for special materials. Owing to its freedom from lime it is much more soluble and can be washed out of the goods easier than the lime compound.

Of recent years, methods have come into general use for preparing chlorine and the hypochlorites by the action of electricity on a solution of common salt. This method was largely employed during the recent war as a means of obtaining chlorine for use as a *poison gas*, and has almost completely replaced the former methods which used hydrochloric acid as a starting point. As mentioned when dealing with caustic soda, the electric current splits up the salt into the two substances, chlorine and sodium. If the apparatus be so arranged that these two products are kept quite separate, chlorine gas is evolved at one terminal and can be collected, whilst the sodium liberated at the other terminal immediately acts upon the water, forming caustic soda. By using suitable arrangements these two products can be made to mix with one another with the result that a solution of hypochlorite of soda is obtained which can be used for bleaching. The salt solution is pumped continuously through the electric *cell* until a large proportion of the salt it contains has been converted into hypochlorite, and is then run off for use. This process is usually carried out by the bleacher himself, as the solution does not keep very well and should be used as soon as possible.

Hydrogen Peroxide. This is the other main oxidising bleach and has the advantage over bleaching powder that it can be used for both vegetable and animal fibres. It is unfortunately much more expensive than bleaching powder so that its use is restricted to better class materials.

It was formerly obtained from the makers as a very weak solution of hydrogen peroxide in water, but this had serious drawbacks as the solution did not keep well, and, owing to its bulky nature, was very expensive in carriage. At the present date it is usually prepared as required by the bleacher himself from the substance known as sodium peroxide, which is a yellowish-white powder and keeps quite well in sealed tins.

All that is required to prepare a solution of hydrogen peroxide from this substance is to stir some of this powder into water to which the proper amount of sulphuric acid has been added. The acid converts the soda compound into hydrogen peroxide and sulphate of soda.

Reducing Bleaches. These are mainly employed for the animal fibres which cannot be bleached with the cheap bleaching powder.

The most important, and the one which has been in use for many centuries, is the so-called *Sulphur Bleach,* which really consists in submitting the material to the action of the fumes produced by burning sulphur in air. These fumes are a compound of sulphur and oxygen known as sulphur dioxide and have a very pungent and irritating odour. In some cases, instead of using this substance in the form of a gas, its solution in water is employed under the name of the *liquid bleach* as distinguished from the usual *gas bleach.*

The sulphur bleach is not much used for vegetable fibres except where the latter are mixed with animal fibres in a union material, as mineral acid is formed which is liable to injure the vegetable fibres although it has no injurious action on animal ones.

Other reducing bleaches, e.g. sodium hydrosulphite, have been introduced during recent years, but their expense is against their general use.

OILS, FATS, WAXES AND SOAPS

Owing to the fact that fatty and waxy substances form a large proportion of the impurities present in raw textile materials, and that soaps of various kinds play a considerable part in the actual cleansing operations, a brief description of these substances may be of assistance in rendering the processes more intelligible to the reader.

All true fats, using the word in its strict sense, consist essentially of compounds of substances known as fatty acids with the well-known sweet substance glycerine. Some fats are solid at the ordinary temperature whilst others, e.g. olive oil, are liquid.

The mineral oils, e.g. paraffin, are of quite a different chemical composition and contain no combined glycerine.

If a fat, e.g. olive oil, be boiled with a solution of an alkali like caustic soda, the fat is gradually split up into glycerine, which remains dissolved in the solution, and fatty acids which combine with the alkali employed to form compounds known as soaps.

If the alkali used be soda or potash the soaps formed are soluble in water, so that if a textile material contain fatty impurities of this character they can be removed by boiling the material with one of these alkalies and then washing with water in order to remove the soluble soaps formed. As will be seen later, this process can only be employed with vegetable fibres as animal fibres would be destroyed by the alkali.

If a solution of lime be used in place of soda or potash a soap would also be formed, but would be a compound of lime with the fatty acids present in the fatty matter and usually insoluble in water. This process of splitting up fats by boiling with alkali is termed *saponification* from the Latin name for soap.

The mineral oils are not affected by boiling alkalies and cannot be removed from textile materials in the above manner. They are, of course, not naturally present in the raw fibres but they are frequently added to the sizing pastes used in the preparation of vegetable fibres for weaving and are also often found on the material as oil stains from the lubricating oil employed in the machinery. Owing to the difficulty with which they are removed their presence should be avoided so far as possible.

Soaps. As mentioned above, soaps are formed by the action of alkalies upon fats and this is the method usually employed in practice in the manufacture of soaps for cleansing purposes. The fats employed are usually vegetable oils such as olive oil, cotton seed oil, etc., or else animal fats and oils, e.g. tallow and fish oils. If soda be the alkali used the soaps formed are usually *hard*, but if potash be taken, especially with liquid oils, the soaps are usually very soft and jelly-like and are called *soft soaps*.

MANUFACTURE OF HARD SOAP. The oil or solid fat is placed in a suitable boiler along with the necessary quantity of a solution of caustic soda and the mixture boiled until the fat is completely split up or saponified. The *soap pan* now contains a solution of soda soap mixed with all the glycerine originally present in the fat and any excess of soda which may have been taken. In order to recover the glycerine, which is a very valuable by-product, common salt or a strong brine solution is run into the pan containing the boiling soap solution and the mixture allowed to cool. The soap is usually insoluble in the brine solution and rises to the top of the mixture as a pasty mass, whilst the glycerine, together with any excess of alkali, remains dissolved in the heavy brine liquor at the bottom of the pan. The brine layer is run off and worked up for the recovery of glycerine, whilst the upper pasty soap layer is treated further in order to remove any unsaponified fat or excess of alkali and finally run into *frames* where it sets to a solid mass. In making soft soaps with potash it is impossible to *salt out* the soap with brine as this would convert the potash soap into a hard soda soap. A solution of potassium chloride can be used but is expensive and, as a general rule, no attempt is made to remove the glycerine, etc., and the resulting soft soap contains everything that was put into the boiler.

Resin Soap. If resin be boiled with caustic soda a resin soap is obtained which has very strong cleansing properties and is much used in cotton bleaching.

Waxes. These, like the fats, usually contain fatty acids but, in the case of the waxes, these are not combined with glycerine but with other substances of a somewhat similar character.

Most of the vegetable waxes can be at least partially saponified by boiling alkalies but they are more difficult to remove from textile materials than are the fats.

The mineral waxes, e.g. paraffin wax, are not affected by alkalies and are very difficult to remove. They are sometimes used in sizes but should be avoided.

WATER

The question of water supply is of the greatest importance in the choice of a site for a works for textile bleaching. Not only is a plentiful supply of water needed at all times of the year, but the quality of the water has great influence on the success or otherwise of the operations.

The impurities which are likely to be present in the water available are of two kinds—

1. Suspended impurities, e.g. sand, mud, etc.
2. Dissolved impurities of various kinds.

Those of the first class are of comparatively little importance and can usually be easily removed by simply allowing the water to stand for some time in tanks, so that the solid matter may settle to the bottom, after which the clear supernatant water can be run off for use through suitable pipes. The dissolved impurities are much more difficult to remove and usually necessitate chemical treatment of the water. They consist mainly of soluble salts of lime, magnesia and iron derived from the soil through which the water has passed.

The different bleaching operations are affected to a very different extent by the presence of these in the water and in some cases their action is quite negligible, whilst in others they are the cause of great trouble and expense. The operations most affected are those in which soap is used. As already explained, ordinary soap is a compound of soda or potash with various substances called fatty acids. These soaps are soluble in water, but if the water contains soluble salts of lime or magnesia a chemical action takes place, and the soda or potash in the soaps is replaced by the lime or magnesia with the formation of lime or magnesia soaps which are insoluble in water and have therefore no cleansing action upon the material under treatment. This, of course, entails a waste of soap which can be better appreciated when it is stated that an amount of lime or magnesia salts in the water equivalent to one pound of chalk will neutralize and waste about ten pounds of ordinary soap. Many waters contain the equivalent of more than twice this amount of chalk in a thousand gallons and as the water used in a big works may amount to many thousands of gallons per day, it is easy to see what an expensive matter this may be to a manufacturer using much soap. Not only is the loss of soap to be considered but, unfortunately, the lime and magnesia soaps formed are of a sticky character and frequently remain adhering to the goods, from which they are removed with difficulty. The scum formed on the surface of hard water when it is used with soap consists of these insoluble soaps.

The use of soap is restricted chiefly to the cleansing of animal fibres and the impurities in the water are fortunately of much less importance when dealing with the vegetable fibres.

The presence of alkaline impurities such as the bicarbonates of lime or magnesia causes a loss of acids during the souring operations, but as the ordinary acids are much cheaper than soap this is not so important and a water may be used in bleaching vegetable fibres which would be quite out of the question if wool or silk, which need large quantities of soap, were to be treated. If the water contains iron it sometimes causes stains in white goods.

So far, only the effect of the impurities in the water on the actual bleaching operations has been considered but there is another very important use of water in connection with bleaching generally.

Most bleaching operations require the use of large quantities of steam, either for heating the various liquids employed, or else to drive the necessary machinery. When ordinary water is heated in a boiler it is converted into steam and passes away in the form of vapour, but any mineral impurities which it may contain remain in the boiler. As more water is being added continuously to the boiler and driven off as steam the result is that these mineral impurities accumulate in the water remaining in the boiler. This water can only dissolve a limited amount of these impurities so that, after a time, they begin to separate out from the solution in the solid state, which sometimes takes the form of a hard crust or scale which adheres to the plates of the boiler, just as a kettle becomes *furred* when used for a long time with hard water.

This coating of scale has two main drawbacks: (1) It is a much poorer conductor of heat than the metal plates, so that a large proportion of the heat in the furnace gases passes up the chimney and is lost instead of passing through the plates to the water, and (2) the boiler plates, being kept from actual contact with the water in the boiler by this layer of badly conducting scale, are liable to become red hot and if, owing to unequal expansion, a crack should form in the scale, the much cooler water would come in contact with the overheated plates, with the immediate production of a large quantity of steam the pressure of which might burst the boiler.

The conclusion to be drawn from the above is that if the water available be very hard it should have its hardness reduced in some manner before use.

The method of purification employed in practice consists essentially in adding certain chemicals to the water so as to convert the dissolved lime, magnesia or iron salts which may be present into an insoluble form, which can then be removed from the water by some mechanical process.

When dealing with a substance such as water which is used in enormous quantities one is naturally restricted in the choice of chemicals to be used for its purification by the question of expense.

On the large scale, the chemicals used are lime, which is very cheap, and carbonate or hydroxide of soda. The effect of adding these chemicals to a hard water in proper proportions is to convert the soluble lime, magnesia and iron salts into insoluble compounds which would, in the course of time, settle to the bottom of the containing vessel leaving the clear purified water above them.

Many types of plant have been designed with the object of effecting this in a reasonable time. As a rule they are fitted with an automatic arrangement for adding the necessary chemicals to the crude water in the proportions indicated by a chemical analysis of the latter. The mixture of crude water and chemicals is then usually run into the bottom of a large vessel through which it gradually rises, thus giving the finely divided precipitate of lime and magnesia salts plenty of time to settle to the bottom. The partially cleared water which rises to the top is then run through some suitable filtering medium to remove the last traces of solid, after which it is ready for use. The sludge at the bottom of the vessel is run off at intervals through a sludge cock.

The ordinary method employed for softening water does not remove every trace of lime and magnesia salts as the precipitates formed are very slightly soluble in water, but the amount left is practically of no account and can be ignored in practice.

Some natural waters are so hard that any method of purification would be much too expensive for use on a large scale and are therefore not suitable for any operations in which large quantities of soap are employed.

In the case of boiler waters, the softening is sometimes carried out in the boiler itself by the addition of chemicals such as soda ash, which precipitate the impurities as a powdery sludge which does not form a hard crust on the plates and can be removed by occasionally blowing off the liquor from the boiler.

CHAPTER III

THE BLEACHING OF VEGETABLE FIBRES

(General)

As mentioned previously, the basis of all vegetable fibres is the substance known as Cellulose, either in its simplest form, as in cotton or linen, or in a more complex condition in such fibres as jute, etc. These complex celluloses closely approach wood in composition.

The main object of bleaching is to free the fibre from all impurities which would interfere with its subsequent manufacture or use.

The actual bleaching processes employed depend, of course, on the impurities which may be present in the material under treatment and these vary much, not only in different vegetable fibres but also, in many cases, in the same fibre, according to the particular stage in its manufacture at which the bleaching is carried out.

Impurities in Cotton. Cotton as gathered from the plant contains on the average only about one third of its weight of cotton fibre or "lint," the remainder consisting of the cotton seeds. The latter, which are a very valuable by-product, as the source of cotton seed oil, are removed from the fibre by the process known as "ginning," which is a species of combing operation, and the fibre is compressed into bales weighing from 500 lb. to 700 lb. and comes into the market in that form.

At this stage the raw cotton is, comparatively speaking, a fairly pure product. Omitting the moisture present, the amount of which depends largely on the atmospheric conditions prevailing at the time, and a very small percentage of mechanically adhering impurities such as sand, portions of seed and leaf, and dirt of various kinds, which are largely removed in the course of the various mechanical processes through which the cotton passes during its manufacture, the impurities which concern the bleacher amount on the average to from 4 to 6 per cent by weight, and consist of more intimately fixed substances the removal of which usually entails chemical treatment.

Speaking generally these. impurities can be divided into the following four classes—

1. Fatty, waxy and resinous substances,
2. Pectic or gummy matters,
3. Mineral matter,
4. The natural colouring matter present in many varieties of cotton.

During the early stages of its manufacture the raw cotton passes through a large number of combing or carding operations the effect of which is to remove most of the loosely adherent dust, etc., and to convert the tangled mass of raw cotton into a long band of *slubbing* or *sliver* in which the individual fibres have been combed out straight and lie more or less parallel to one another. Owing to the absence of twist, this material is very delicate and needs careful handling. The band of sliver thus produced is drawn out still further into fine strands and given a slight twist, and is then called *rovings* which, after further drawing and twisting, form the ordinary yarn or thread.

Cotton can be bleached at all stages of its manufacture—loose cotton, sliver, rovings, yarn, or, finally, piece goods. Cotton in the first four of these stages usually contains only the impurities present in the raw cotton together with a small amount of oil or dirt picked up from the machinery or other sources during the process of manufacture. If, however, the cotton has been woven into cloth, the conditions are usually very different for the following reasons. The threads of yarn which are to form the warp of the cloth, i.e. those which run in the direction of the length of the piece, have to stand a considerable strain and friction during the weaving process, so that it is customary to strengthen and smooth down these threads previous to the weaving by the process known as *sizing*.

The simplest size usually consists of a paste made from some adhesive substance such as flour, starch or gum, the yarn being impregnated with the mixture, well squeezed to remove excess, and finally dried. This strengthens the yarn by binding the individual fibres of which it is composed more closely together and also gives it a smoother surface so that it can run with less friction in the loom. It would not be a very difficult matter to remove a size of this character from the cloth, but unfortunately the manufacturer often wants to increase the weight and improve the appearance of the cloth by adding other material to the size pastes.

The substances used are of a most varied character and include weighting materials, e.g. china clay, and fatty bodies such as tallow, to give a softer feel to the material together with antiseptics to prevent the starch matter present becoming mildewed, and many other substances. It follows from this that cotton piece goods often contain a great deal more impurity than the raw cotton from which they are manufactured and, as will be expected, require a considerably more drastic treatment in bleaching.

In calico printing the cloth being printed is backed by a travelling belt of material known as the *blanket* and this readily becomes soiled with the printing pastes passing through or over the edges of the cloth being printed.

To obviate this it is a common custom to run a piece of unbleached cloth between the blanket and the piece being printed, with the result that this *back grey* becomes loaded with thickening agents, dyes and chemicals of various kinds from the printing pastes in use. Before these back greys can be themselves printed they must of course be thoroughly cleansed and naturally this is a very difficult process.

From the above remarks it is easily seen that the impurities present in cotton goods at various stages of their manufacture are of a most varied character and it naturally follows that the methods employed in bleaching vary very greatly with different materials.

The actual degree of bleaching required for any material depends mainly on the uses to which it is to be put. If it is to be dyed black or in some other dark shade, it is, of course, quite unnecessary to bleach the material quite white and all that is required is to cleanse the material, so far as possible, from all greasy or other impurities which would interfere with the proper fixation of the dye. If, however, the cotton is to be dyed in pale or very bright shades, and especially if it is to be left white, a more thorough treatment is needed and in the latter case all traces of impurity should be removed so far as possible in order to obtain the best and most permanent results.

A thorough bleach is usually also necessary for cloth which is to be printed so that the white may contrast well with the printed colours.

There are countless variations in the bleaching methods employed for cotton but the main principles underlying them all may be briefly stated as follows—

1. Treatment with alkalies to remove fatty, waxy and pectic matters.
2. Treatment with acids to remove mineral matter.

3. Destruction of any residual colour by exposure to the light or by the use of bleaching solutions.

Impurities in Linen. Whilst raw cotton is a fairly pure material this is not the case with linen. The fibre is obtained from the stalk of the flax plant by a series of operations of which the first, the *retting*, is of a chemical character and usually consists in steeping the stalks in water in order to remove a portion of the gummy matter present, which bind the real fibres to the woody portion of the stem. This operation is followed by a number of purely mechanical ones which are intended to remove the woody matter thus loosened and to leave the fibre. Unfortunately, it is impossible to effect this completely, so that the fibre as used in manufacture still contains considerable traces of this woody matter which is often of a yellow or brown colour and appears like small pieces of straw in the manufactured material.

As mentioned previously the linen fibre is not a simple fibre like cotton, but consists of long strands of cells about an inch in length stuck more or less tightly together by means of the gummy matter present. The amount of these gummy or pectic substances in raw linen is very large compared with the amount present in cotton so that the total impurity present may amount to as much as 30 to 40 per cent of the weight compared with about 5 per cent in the case of cotton.

Excluding the traces of woody matter, the impurities present are of the same general character as those found in cotton and may be removed by the same general methods. Owing, however, to the large proportion present their removal is much more difficult than is the case with cotton and this is rendered worse by the fact that, owing to the compound structure of the linen fibre, it is more sensitive to chemicals than the cotton fibre and requires repeated treatments with weak solutions, as, if strong chemical solutions were employed, there would be great danger of weakening the compound fibre and splitting it up into its short constituent cells which would much deteriorate its value.

Other Vegetable Fibres. Of the other vegetable fibres, ramie or china grass gives a practically pure cellulose when bleached, but the others, such as hemp or jute, are of a more woody character and cannot be bleached white by ordinary methods without injury. This is, however, of little importance as they are usually employed in practice in their natural colour, or else dyed in full shades.

CHAPTER IV

THE BLEACHING OF VEGETABLE FIBRES

(Historical Development)

As is the case with many of the useful arts it is quite impossible to state, even approximately, the date of the first introduction of bleaching, but it probably followed very closely on the first attempts at weaving textile materials

So far as the vegetable fibres are concerned, the one in general use in Europe up to the middle ages appears to have been linen, the use of cotton having been largely confined to India and the East previous to that date An examination of the bandages employed by the ancient Egyptians as wrappings for their mummies proves that they had made very considerable progress in linen manufacture some thousands of years before Christ and it is evident that they were acquainted with methods for bleaching it

Living as they did in a country blessed with very brilliant sunshine they probably observed the whitening action of light on coloured materials at a very early date, and this would doubtless suggest to them what is without question the most primitive method for bleaching, namely the exposure of the linen cloth to the action of sunlight by spreading it out on the fields It is an interesting fact that this ancient method still survives at the present day not only in domestic bleaching but also on the big scale in the *grassing* or *crofting* of linen

In many parts of the world, especially in hot climates, the soil frequently contains considerable amounts of alkaline substances such as carbonates of soda or potash, and the cleansing action of these was discovered very early, so that the exposure of the woven materials to the action of sunlight was probably combined with a previous treatment of the cloth in a mixture of these alkaline earths and water. This method is actually employed at the present day in some parts of the world. These alkaline earths seem to have arisen from the drying up of inland waters containing these alkalies in solution and it may be mentioned that there are enormous deposits of impure carbonate of soda at Lake Magadi in Upper Egypt which are at present being worked on the large scale for the production of soda.

These natural deposits of soda were of only local importance and as the manufacture of sodium carbonate from common salt was only introduced at a comparatively recent date, the bleacher had to obtain alkali from other sources. The substances in general use were potash and, perhaps, lime. Vegetable matter such as wood always contains a small proportion of potash salts obtained from the soil, and if the wood be burned this potash remains behind in the ash. In order to obtain potash the wood was burned in iron pots leaving an ash which consisted mainly of an impure carbonate of potash. The name *potash* originated from this method of manufacture. By treating the ashes with a little water the carbonate of potash dissolved along with a portion of the other substances present and on evaporating the clear solution a purer product, known as *pearlash*, was obtained.

So far as Europe is concerned the main seat of the industry of linen bleaching until the last century or so was Holland, whose bleachers had obtained a great reputation, but, at the present date, the bleaching is usually carried out in the same neighbourhood as the manufacture of the material. Even as recently as the eighteenth century the linen woven in Scotland was sent to Holland to be bleached.

The methods employed varied considerably in different localities but a general idea of the process used will be obtained from the following description.

The cloth was first steeped for some time in a weak *lye* made from wood ashes, which had already been used for a previous batch of cloth, and was then treated with a freshly prepared lye which was poured on boiling hot and left for some days or a week. This alkaline treatment softened and dissolved the greasy and gummy impurities present in the cloth and was followed by a thorough washing with water. The next step was to soak the cloth for a prolonged period in sour milk from which the cream had been carefully removed. The acids present in the sour milk gradually dissolved the mineral impurities present. After another wash with water and sometimes with soft soap, the cloth was spread out on the fields and exposed to the action of the light and weather for some weeks, being kept moist by frequent sprinklings with water.

The water was usually obtained from small canals which ran through the bleach grounds, and was scattered over the linen by means of long wooden scoops or shovels.

The various operations above described were repeated several times until the linen was white enough, so that the process was very prolonged and, in fact, usually occupied several months. The Scotch linens which were sent to Holland about March were returned bleached about October.

In this prolonged process we have the basis of the methods employed at the present day : Treatment with alkalies, treatment with acid, and removal of residual colour.

During the eighteenth century various improvements were made in this process which had the effect of considerably shortening the time required. Instead of simply steeping the material in the lye it was found that the action of the latter was much more efficient if the material were actually boiled in it. This operation was known as *bucking* or *bowking* and these names still persist at the present day. The origin of these names is not quite clear. According to some authorities they are derived from the Anglo-Saxon *buc*, meaning " a pitcher " and so connected with such words as *bucket*. They were probably first applied to the actual vessels in which the boiling was carried out and their meaning was later extended to denote the actual process itself. According to another authority, it is connected with the Celtic word *buac* which means " dung " and arose from the old Irish method of bowking the linen with cow-dung and water.

In some cases the alkaline lye used was strengthened in its action by the addition of a little lime which, as we now know, converts a portion of the carbonate of potash into the hydroxide or caustic potash which is considerably more energetic in its cleansing action. At first there was great opposition to the use of lime as it was supposed to injure the material.

According to an Act of Parliament passed early in the eighteenth century, " Lappers may enter into Buck-houses, Bleach-yards, and other places and search the same for Lime, pigeons dung and soap dregs, and upon proof before one or more Justices of the Peace or ' Magistrat of Burrows,' that any of the above materials have been mixed or used with any Lees in bleaching, the offender shall forfeit £5 sterling, and the cloth or yarns so bleached to the informer, and be rendered incapable to Bleach for two years following."

Attempts were made to enforce this law in 1815, but without success, and the use of lime rapidly spread owing to its cheapness compared with potash.

The bleaching process was still further shortened by the replacement of the sour milk treatment by a soak in dilute sulphuric acid which, owing to its much stronger action, cut down the souring process from weeks to a few hours. This improvement was due to Dr. Home of Edinburgh, about the year 1756. When cotton came into general use it was bleached by very similar methods to those used for linen, but, owing to its greater purity, the processes were considerably shortened. Another step forward was the commercial production of carbonate of soda on the large scale from common salt, with the result that this substance soon took the place of the more expensive potash compound.

The outstanding landmark in the history of the development of cotton and linen bleaching is the introduction of the chlorine bleach.

Until nearly the end of the eighteenth century the destruction of the natural colour of cotton and linen was always effected by prolonged exposure of the material to the action of sunlight which, as mentioned previously, was a very slow process.

In 1774, the Swedish chemist Sheele discovered the gas which is now known as *Chlorine* and noticed that it was able to decolorize many vegetable colours, but the first suggestion of its use as a bleaching agent on the practical scale appears to have been due to the famous French chemist Berthollet in 1785.

The chlorine was first used in the gas form and had to be prepared by the bleacher himself as required, but anyone who has worked with chlorine gas will easily understand the difficulties which such a process would give rise to in practice. A slight improvement was effected by passing the gas into water and using the solution thus obtained, but this also had a most injurious effect on the workpeople. The gas was prepared by heating a mixture of common salt, sulphuric acid and manganese ore in a retort and passing the gas evolved into water in which it dissolved.

The material to be bleached was first treated with hot potash lyes, as described above, and then immersed for some time in the chlorine solution, these operations being repeated until the material was white enough.

The following quotations from a book on bleaching by a Frenchman, *Pajot des Charmes*, which was translated into English in 1799, will give some idea of the difficulties under which the early workers with the process laboured.

" The oxygenated muriatic acid (chlorine) has a most penetrating odour and cannot be breathed even for a few instants without the danger of a most obstinate and irritating cough. Its action is sometimes so strong that the operator will fall down senseless. Running at the nose, asthmatic affection of the breast, headache, tears and smarting of the eyes, bleeding at the nose and even spitting of blood are the ordinary inconveniences to be expected."

The author goes on to state : " The difficulty, or rather the impossibility of supporting such painful exertions for any length of time, induced me to contrive a mask of card, with glass eyes, which allowed me, for a certain space, to work with my face over the vessels for the immersion of the goods, to turn, press and ring the pieces without fear of any serious inconvenience. I likewise occasionally made use of a handkerchief moistened with alkaline lixivium, which I bound round my head to defend my nose and mouth from the effects of the odour, but these means were only palliatives."

The above quotations will give the reader an idea of the great difficulties which beset the pioneers in the use of chlorine for bleaching, and it is easy to see that a process in which the workmen had to labour in an atmosphere similar to the "poison gas" used by the Germans in the late war was quite impracticable for general use

It is very interesting to see from the above quotations that gas masks and respirators were in use even at that early date

The whole difficulty arose from the use of the chlorine in the free state, and it was overcome when it was discovered that by combining the chlorine with other substances its offensive fumes could be almost completely suppressed whilst its bleaching properties still remained and were, in fact, more easily regulated than when the free gas was employed

Apparently the first step in this direction was the use of a weak solution of potash to dissolve the chlorine in place of the water which had been employed up to that time The product, which is now known to be mainly a solution of hypochlorite of potash, was called "Eau de Javelle" and had strong bleaching properties along with very little objectionable smell The expensive potash was soon afterwards replaced by soda The well scoured material was soaked in these solutions for some hours and then given a good wash with water, repeating the operations if necessary

The chlorine bleach appears to have been introduced into Scotland by the famous engineer James Watt, who met Berthollet when on a visit to Paris in 1786 and learned the new process from him On his return to this country Watt explained the new process to his father-in-law, Mr McGregor of Glasgow, who started to use the process on the large scale in 1787. It was introduced into the Manchester district about the same time by a Mr. Henry.

Both the alkalies above mentioned were expensive and attempts were made to replace them by the much cheaper substance, lime, and in 1798, Charles Tennant of Glasgow, took out a patent for a bleaching solution made by passing the chlorine gas into lime water.

This patent was annulled in 1802, but in 1799 Tennant had taken out another patent for the manufacture of a dry bleaching powder by passing the gas over slaked lime. As this substance is fairly stable and easily transported it soon came into large use and did away entirely with the necessity for the bleacher to prepare his own chlorine. Since that date " bleaching powder," as it is called, has held the field for cotton and linen bleaching with practically no competitor until quite recently, when the introduction of electrolytic methods for preparing hypochlorite of soda on a large scale has caused the latter substance to take the place of bleaching powder to a small extent for special purposes where its extra cost is justified by the advantages in its use due to its freedom from lime.

Since the introduction of the chlorine bleach there have been very few important advances in the bleaching process from the chemical standpoint. The main aim of inventors during the last century has been to improve the mechanical side of the process in order to cope with the greatly increased output now necessary and to obtain greater regularity in the results.

As previously mentioned the simple steeping of the goods in the alkaline lyes was replaced long since by an actual boiling process which much increased the cleansing action. About 1844, the process was again improved by boiling the material in closed vessels under increased steam pressure which, as will be explained later, gives a much higher temperature and a more intense action.

It had been the custom in some works to strengthen the action of the potash or soda lyes by the addition of a little lime. This really converted a portion of the alkali carbonates present into hydroxides or caustic alkalies which had a stronger cleansing action than the carbonates. This fact led to the use of caustic soda by itself as a scouring agent, and at the present date it is used in enormous quantities either by itself or along with soda ash. Another improvement was the addition of resin to the boiling lye. This appears to have been introduced about 1840, and owes its use to the fact that it forms a resin soap with the caustic alkali which has a very strong action on certain of the impurities which are present in the material.

Some of the main improvements in the mechanical plant employed will be described later when dealing with the actual bleaching process.

CHAPTER V

PRACTICAL COTTON BLEACHING

THE most important operation in cotton bleaching is not, curiously enough, the actual destruction of the natural colour of the cotton, but the cleansing operations which are preliminary to this.

In order to obtain satisfactory results it is essential that the material be thoroughly cleansed from all waxy, oily or resinous impurities before the actual destruction of the colour by means of bleaching solutions. If these impurities are present in the cloth they render the cotton non-absorbent, interfering with the even action of the bleaching solutions and necessitating the use of stronger solutions which are very liable to injure the cellulose of the cotton fibre owing to the formation of the substance known as oxy-cellulose, which not only makes the cotton weaker but also interferes in many cases with the subsequent dyeing. Even if the cotton is to be left white, the presence of this oxy-cellulose tends to make the material turn yellowish after a time.

As already mentioned, the cleansing operations consist essentially of successive treatments with alkaline and acid solutions. The alkaline treatments are in nearly all cases carried out at the boil as it is found that the hotter the solutions used the more rapid is the cleansing action.

In early days this boiling was carried out in open vessels which were heated by means of direct fire, but this method was only suitable for quite small lots of material, and even then was very liable to give uneven results owing to the unequal heating of the liquor and the lack of efficient circulation. In some cases the material was packed in the boiling vessel in layers with clean sticks or basket work frames between them in order to keep the material more open and prevent it settling in a tight mass. At the present date, when large production is of the first importance, the boiling or bowking, as it is called, is nearly always carried out in large vessels called *kiers* (Icelandic: *ker*, a vat).

It can be easily understood that to simply heat the liquid in which a mass of cotton is lying would not give satisfactory results with large quantities as, owing to the tightly packed condition of the material, the liquor could only penetrate it with difficulty, and, as it would pass by preference through the less tightly packed portions, the cleansing action would vary in different parts of the mass.

In order to get over this difficulty some method of circulation must be employed so that the different parts of the material may, so far as possible, undergo an equal treatment.

There are two main methods for effecting this: (1) The liquor may be circulated through the material which remains itself in a fairly quiescent state; (2) The material may be circulated through the liquid.

Owing to the fact that the bleaching of cotton cloth is by far the most important branch of the trade this will be dealt with first instead of treating the materials in the natural order of their manufacture. This apparently illogical method of treatment is chosen for convenience in order to avoid repetition, as all the other cotton materials are bleached according to the same general methods, modified to suit the special circumstances.

The largest bulk of cotton cloth is boiled by the first method above mentioned, the liquor being circulated through the mass of material, so that this process will be described first, leaving the other method for later treatment.

The Bleaching of Cotton Cloth. The bleacher has to deal with cotton cloth of the most varied descriptions and qualities. Some of this may only require a simple scour in order to remove the bulk of the grease, size, etc., whilst in other cases it may be necessary to remove practically every trace of impurity so as to leave a material consisting of almost pure cellulose.

It is of course quite impossible to describe the treatment of all kinds of material, but the following account of a *full bleach* will give the reader an idea of the various operations through which the cotton passes.

The cloth, as it comes to the bleacher, usually consists of pieces of very varied qualities and sizes, and it is important that this *grey* cloth, as it is called, should be sorted into batches of pieces which will stand the same treatment. The number of pieces in a batch will depend on the capacity of the plant employed and especially on the size of the boiling kier. These kiers vary very much in capacity but are usually constructed in different sizes to hold from one up to as much as four tons of cloth. For a big kier the batch of cloth may be made up of as many as 200 pieces, and as each of these may be 100 or more yards in length, the total length of cloth under treatment at one time may be as much as 10 to 15 miles. In order that the bleacher may be able to identify the pieces after bleaching they are first stamped at the ends with suitable marks, using some substance, such as tar, which will stand the various bleaching operations without being removed.

As can be easily understood, it would be very difficult, if not impossible, to work so many pieces in one batch if they were kept separate, owing to their liability to become badly entangled during the various operations, and, in practice, they are fastened together end to end so as to form a long band of cloth and pass through all the bleaching operations in this form, which greatly facilitates their handling. The fastening is effected on special sewing machines which stitch the ends of the various pieces in such a manner that the band of cloth will be able to stand the very considerable tension to which it is subjected and, at the same time, the thread can be easily withdrawn, if necessary, in order to separate the pieces.

At this stage the band of cloth is sometimes passed, in the open width, through a beating and brushing machine in which process the cloth loses a considerable amount of dust and dirt of various kinds which would otherwise have to be removed in the later operations.

A much more usual operation preparatory to the bleaching proper is the *singeing.*

Singeing. As the pieces come from the loom the surface of the material is more or less covered with a nap of projecting fibres, and if the latter were not removed they would interfere with the use of the cloth if it were to be printed, as the loose fluff would spoil the sharp outlines of the patterns. In many cases also the cloth is required to have a quite clean surface for use as linings, sateens, etc., so that this fluffy matter must be removed by some means.

In the old days this fluff was removed by passing a red hot piece of metal, shaped something like a soldering iron, over the surface of the cloth by hand. This method is, of course, out of the question for large scale production and, at the present date, the singeing is carried out mechanically by two main methods—

1. Plate singeing.
2. Gas singeing.

Plate Singeing. The cloth is passed in the open width over the surface of one or more curved copper plates which are kept at a red heat by the flames from a coke or oil furnace which pass beneath them. If the cloth remained at rest in contact with the red hot plates it would, of course, soon catch fire, and to prevent this, the cloth is passed over the plates at a speed of from 150 to 200 yards per minute and the singed cloth is at once run into a box in which it is damped with water or steam in order to extinguish any sparks.

If the cloth were always run over the same portion of the plates the latter would soon become worn by the friction and would also soon drop in temperature owing to the rapid passage of so much cold cloth. To obviate this as much as possible a jigging motion is usually fitted to the guiding rollers which lead the cloth over the plates so that a fresh uncooled surface is continually presented to the cloth.

If it be desired to singe both sides of the cloth the latter is simply reversed and run a second time through the machine.

The annexed diagram of a two-plate singeing machine shows the band of cloth passing over the two heated plates (AA) and then between the rollers (B), the lower of which is immersed in water in order to extinguish any sparks.

Gas Singeing. When using this process the singeing is carried out by passing the cloth through or against a smokeless gas flame from a bunsen burner. The coal gas, mixed with air, is supplied under pressure to a long slit-shaped burner which extends the whole width of the cloth. The latter is either run directly through this flame or else passes over metal rollers so arranged that the flame plays upon the surface of the cloth. Owing to the admixture with air the flame is free from soot and has a very high temperature, so that the projecting

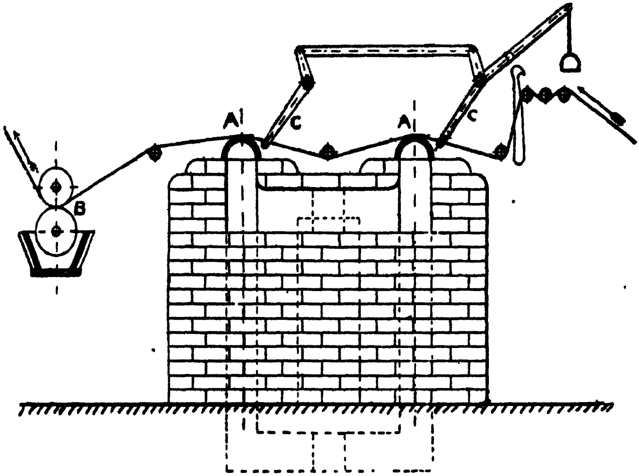
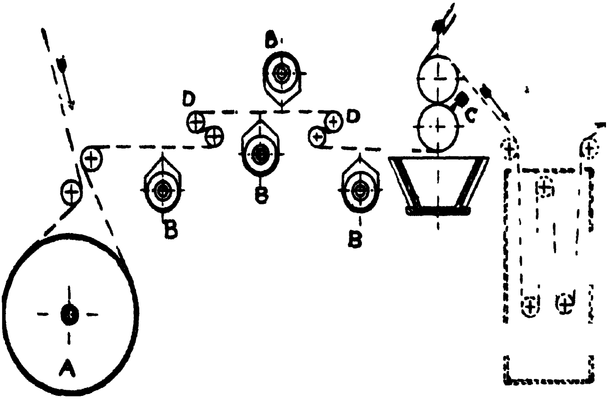


PLATE SINGEING MACHINE
(Sir James Farmer & Sons)



FOUR-BURNER GAS SINGEING MACHINE
(Sir James Farmer & Sons, Manchester)

fluff is rapidly burned off. By passing the cloth over suitable guide rollers and having one or more of the gas-burners inverted the cloth can be singed on both sides during a single passage through the machine. Owing to the penetrating action of the flame the singeing action is more drastic than is the case with plate singeing and impoverishes the cloth more than the latter.

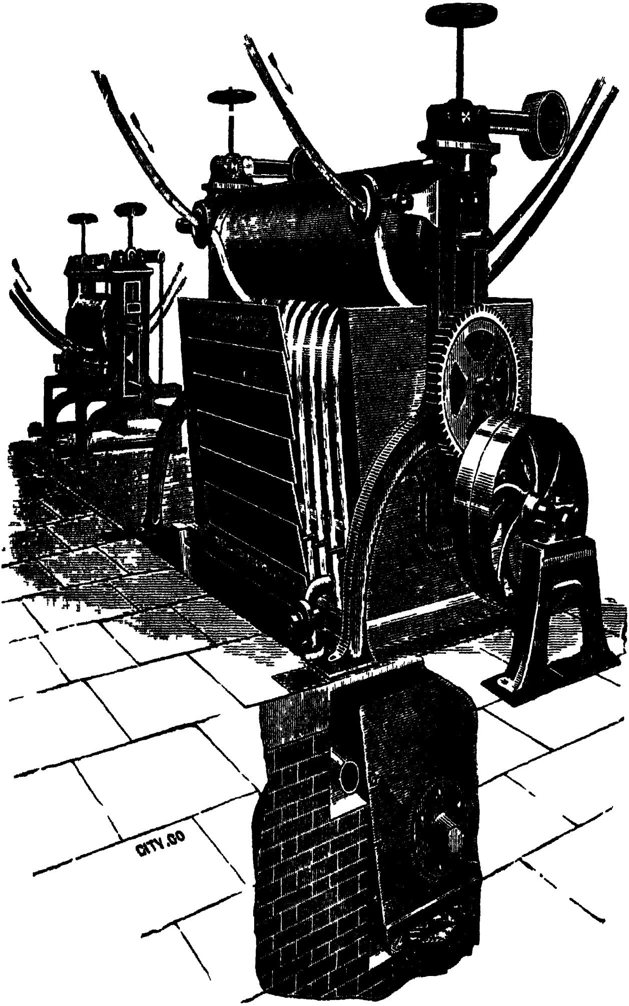
In the diagram given of a four-burner singeing machine made by Sir James Farmer & Sons, the cloth passes first over a steam heated cylinder (A) in order to dry it and then through the burner flames (B), which are so arranged that three of them singe the cloth on one side and one on the other. It then passes between the two damping rollers shown or else into a steaming box to extinguish sparks.

If the warp yarn used in the manufacture of the cloth has been sized with mixtures containing such substances as magnesium chloride they must be removed preparatory to the singeing by washing with water and drying, as the heat of the singeing would decompose the chlorides, setting free hydrochloric acid which would rapidly tender the cotton.

For some classes of cotton material this singeing process is quite unnecessary and is omitted.

Owing to the considerable risk of fire in this process it should be carried out in an isolated building.

Up to this point the long band of cloth has been kept tightly stretched in the open width but for the following operations, as usually carried out in practice, this is impossible. The long band of cloth is run through rings of glazed earthenware, known as *pot eyes*, which cause the band to take the form of a long spirally twisted rope, in which condition it passes through all the bleaching operations proper, being run from one machine to the next over wooden winches or reels which are supported



WASHING MACHINE WITH DEEP BOX

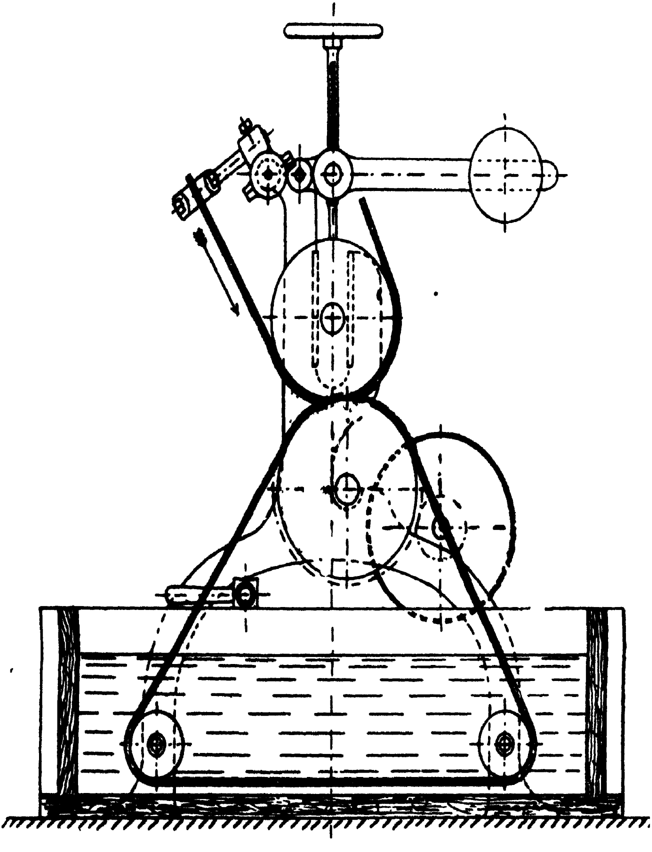
(Sir James Farmer & Sons)

on brackets fixed to the walls or roof of the building so as to be out of the way of the workers. As the band of cloth is run at the rate of 100 to 200 yards per minute it would be a source of considerable danger if it were not well raised above the floor.

The movement of the cloth from one process to the next is effected partly by the friction of the winches, which are driven by power, and partly by the drag exerted by the washing machines through which the band of cloth passes several times in the course of the bleaching. These washing machines are of great importance in the production of a perfect bleach. They consist essentially of a trough or tank above which are placed two wooden rollers which act both as squeezing rollers and also as transmitters of the cloth. The lower roller is usually driven by power whilst the upper one is driven by the friction of the lower. The pressure between the rollers can be adjusted by means of levers or springs.

Two ropes of cloth are usually run through the machine at the same time, one entering at each side of the machine through a pot hole, passing through the nip between the rollers and then down into the water trough below. After passing through the water over a guide roller the cloth enters the nip again from the other side. This process is repeated several times so that the band of cloth passes along the rollers in a spiral form, being alternately run through the water and then squeezed between the rollers, leaving the machine at the centre in a well-squeezed condition.

This machine exerts a very considerable drag on the cloth, and for delicate materials a *slack washing machine* is employed in which, after passing the cloth through the nip, a certain amount of slack is allowed to collect in the trough before passing the end again through the nip, so that there is very little strain on the material. The



WASHING MACHINE WITH SHALLOW BOX

(Sir James Farmer & Sons)

spiral bands of cloth which are running from the rollers to the trough are prevented from becoming entangled by passing them through a number of pot holes or else by a *peg-rail* which keeps the strands separate by means of a row of wooden pegs.

The alternate washes with water and squeezes in the washing machines have a very effective action in removing any soluble or loose impurities from the cloth.

To return to the description of the actual process, the cloth, whether singed or not, has next to pass through a series of cleansing operations in order to remove the various impurities. In many cases the cloth is run at once, after singeing, to the *alkali boil*, but, if time permits, the latter operation is much facilitated by submitting the material to a preliminary *steeping* process. In its simplest form, this consists in running the rope of cloth through water in an ordinary washing machine and then allowing it to lie, in the wet condition, for some hours or overnight. This process has a softening effect on the starchy matter present in the size, as a kind of fermentation is set up which changes the starch into substances of a sugary character which are soluble in water. A thorough washing with water in a washing machine follows the steeping and removes a considerable portion of the partially loosened insoluble impurities along with any soluble matter. In some cases alkalies such as soda, or weak acids are added to the steeping water in order to increase its action.

We now come to the most important operation in the whole bleaching process, namely, the *alkali boil.*

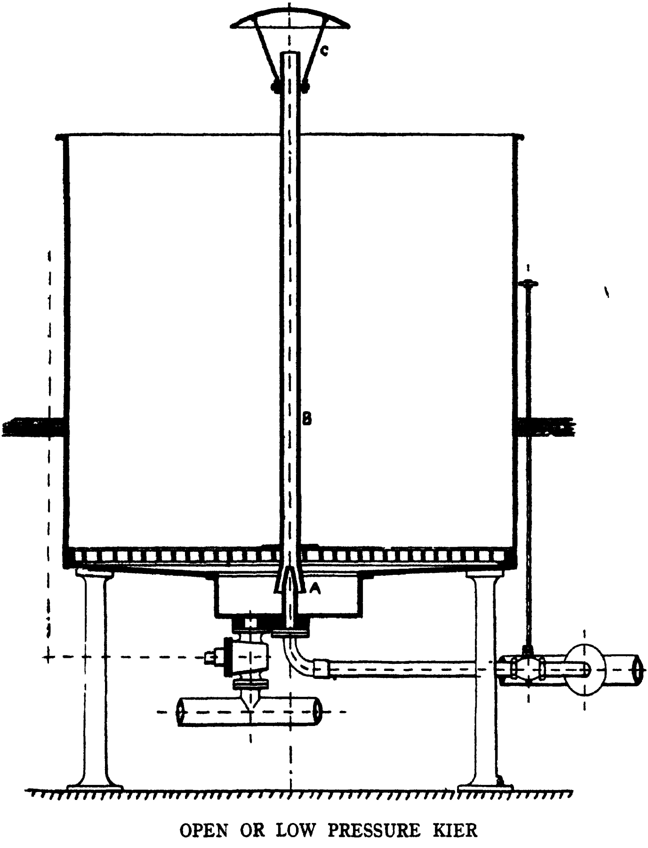
The full bleach which is here described is distinguished from other less thorough bleaching processes by the use of lime as an alkali in the first boil. As already mentioned, lime is very slightly soluble in water and in order to get sufficient of it in contact with the cloth it is used in the form of *milk of lime,* which is a milky liquid containing most of the lime in the form of very finely divided particles. If the lime liquor were placed in the boiling vessel and the cloth simply run into it, it would be quite impossible to get an even distribution of the lime through the mass of the material as the latter would act as a strainer and filter the liquor, thus leaving the bulk of the undissolved lime on the surface of the pile of cloth. To obviate this, the cloth is impregnated with the lime liquor previous to running it into the boiling kier. The *liming* machine used for this purpose is similar in construction to the washing machines already described. The necessary amount of lime is taken and ground up with water so as to form a lime milk of the correct strength and this is run into the trough of the liming machine in a continuous stream whilst the cloth is being passed through. The squeezing rollers force the lime well into the cloth and at the same time remove excess of liquor, so that the lime becomes equally distributed throughout the cloth which is then run directly over a winch into the boiling kier.

The most usual type of kier consists of a vertical cylindrical vessel constructed of steel or iron plates and holding from one to four tons of cloth. The latter usually rests on a perforated false bottom placed in the lower part of the kier so that the liquor can pass through the perforations on its way to the system of circulating pipes. The top of the kier is made either open or closed according to the method of working and, in the latter case, man-holes are usually fitted to give access to the interior.

The rope of impregnated cloth is run into the kier through these openings and packed as evenly as possible by boys who stand inside the kier and arrange the cloth in layers by means of small sticks. When the kier is fully charged, water is run in so as to cover the pile of cloth and the heating and circulating processes started.

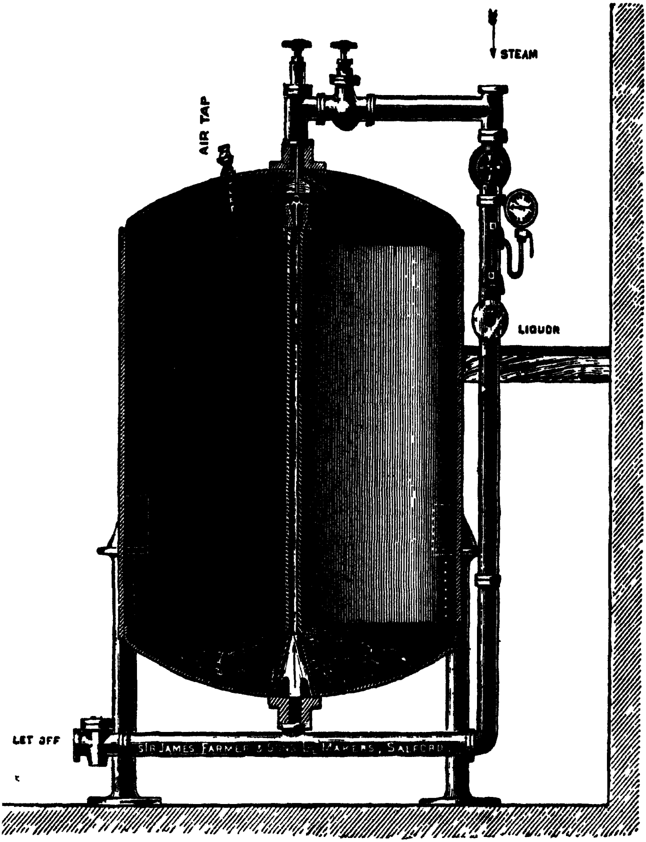
There are two main methods for effecting the circulation of the liquor: (1) by means of steam jets or injectors; (2) by means of pumps. One of the simplest forms of the first class is the *vomiting kier*, so named from the intermittent character of the circulation. A feature of this kier is the *puffer pipe*, which is about 4 in. in diameter and runs vertically upwards through the centre of the kier. It starts at the bottom, passes through the false bottom and terminates above the surface of the cloth. The liquor which sinks through the false bottom enters this pipe through suitable openings and rises in it to a height which depends upon the level of the liquor in the kier. A small steam jet is fitted in the lower part of the puffer pipe, and when the steam is turned on the jet of steam heats the column of water in the puffer pipe up to the boiling temperature, whereupon the water in the pipe is ejected bodily through the open upper end of the pipe against a spreading plate which distributes it over the surface of the cloth. The removal of the liquid from this pipe allows more to enter from under the false bottom thus causing the cloth in the kier to sink somewhat, after which the whole process is repeated. The liquid ejected over the surface of the cloth gradually finds its way through the mass of cloth so that an intermittent circulation is maintained. The steam not only effects the circulation of the liquor, but at the same time raises its temperature.

These kiers, being worked at ordinary atmospheric pressure, are either open at the top or are fitted with a light movable lid in order to prevent unnecessary loss of heat and to exclude air from the goods so far as possible.



OPEN OR LOW PRESSURE KIER

(Sir James Farmer & Sons)

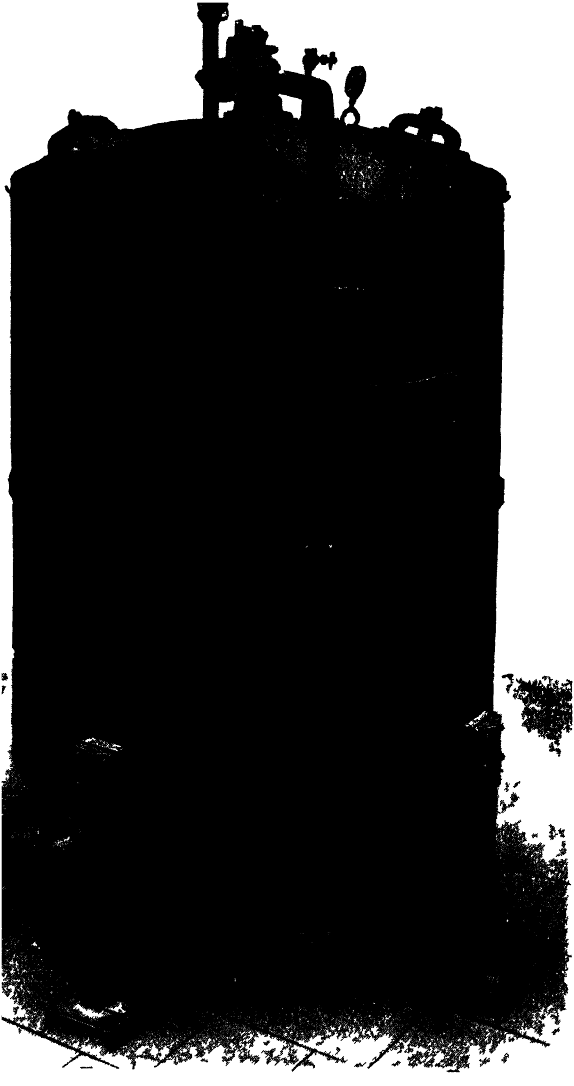


HIGH PRESSURE KIER

A more usual method for effecting the circulation of the liquor is by means of a steam injector. In this form, the puffer or distributing pipe can either be run up the centre of the kier as just described or else run up outside the kier which it enters at the top. In either case the action is the same. The liquor from the bottom of the kier passes into a pipe of special shape, in which it meets a jet of high pressure steam emerging with great velocity from a conical nozzle. This forces the liquor up the pipe in a continuous stream and showers it over the cotton in the kier and at the same time sucks the liquor from under the false bottom, thus aiding the circulation. The injector kier is suitable for use at low or high pressures, which is a great advantage as will be seen from the following.

As already mentioned, the hotter the solutions employed the stronger is their cleansing action. In open kiers the temperature of the liquor cannot exceed about 100° C. (212° F.), which is the boiling point of pure water under normal conditions. In order to get higher temperatures the kiers must be closed so that the steam cannot escape but fills the space above the liquor and exerts a pressure which raises the boiling point of the liquor to a degree which depends upon the pressure of the steam used in the kier. Whilst water in an open vessel boils at about 100° C. it does not boil until the temperature reaches about 120° C. if the pressure of the steam above the liquor be about 15 lb. to the square inch, whilst at 30 lb. pressure it boils at about 134° C. and so on. Of course the use of such high steam pressures necessitates very massive construction in order to withstand the outward pressure on the walls of the kiers, which are often made of steel and usually have rounded tops and bottoms in order to strengthen them.

There are various drawbacks to the use of a current of



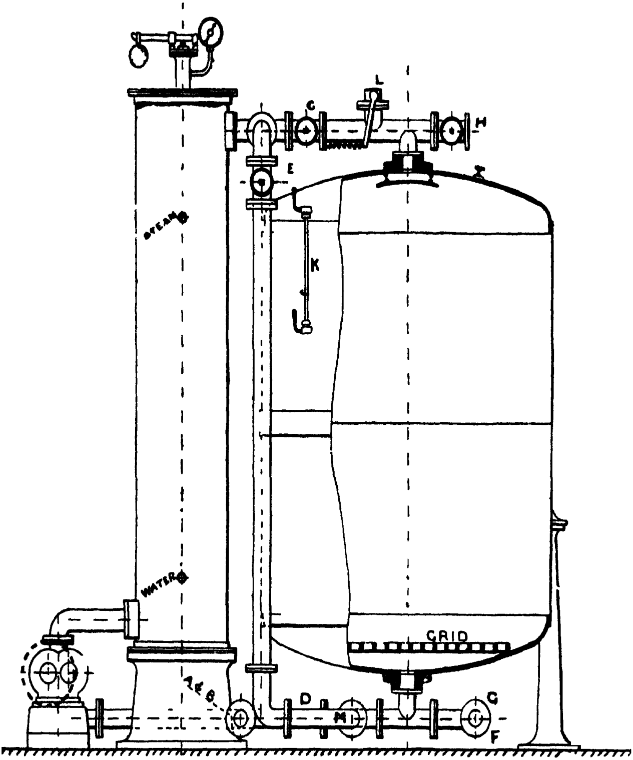
HIGH-PRESSURE INJECTOR KIER

steam in order to circulate the liquor. One is that the steam condenses in the cooler liquor until the latter has been heated up to its boiling point, so that the volume of liquor in the kier is increased and the solutions employed weakened in strength. Another trouble is that the heating and circulation are not under separate control.

Of recent years these difficulties have been overcome by using a centrifugal pump to circulate the liquor and having a separate heating arrangement outside the kier.

The pump sucks the liquor from the bottom of the kier and passes it up through an external heater which consists of a cylindrical metal vessel containing a number of closed steam pipes round which the kier liquor is circulated. As the steam pipes are supplied with high pressure steam the kier liquor becomes rapidly heated during its passage to any desired temperature before returning to the kier through the usual distributing arrangement in the upper part of the latter. This system allows of much better control of the working conditions than is the case with the kiers previously mentioned, as in their case the circulation is largely dependent on the temperature of the liquor.

The kier, being charged with cloth and liquor, is closed, and any air present is expelled by blowing in steam. If this were not done the cloth would probably become tendered owing to the action of the air in presence of the boiling alkali. Of course this does not apply to open low-pressure kiers. The heating and circulating arrangements are started and continued for eight or more hours according to the steam pressure employed. About 20 to 40 lb. to the square inch is a usual pressure. The lime boil decomposes the fatty and waxy impurities present, converting them partly into lime soaps which remain sticking to the cotton until they are removed by



HIGH-PRESSURE KIER WITH MULTITUBULAR HEATER
AND FORCE PUMP
(Sir James Farmer & Sons)

a later operation. This lime boil is really a preparatory operation and appears to facilitate the removal of the impurities in the subsequent processes, but the cotton usually looks even dirtier after the lime boil than before.

On the completion of the boiling the liquor is run off and the kier at once filled with water which is, if possible, circulated through the goods so as to wash out some of the lime and other impurities and at the same time to prevent the cloth becoming damaged by contact with the hot dry walls of the kier after running off the liquor. The kier is then opened and the rope of cloth run out over a winch and passed through one or more washing machines supplied with plenty of water which removes more of the lime together with other impurities loosened by the lime boil.

The washed cloth is then passed through the process known as *souring*, which consists simply in running it through a washing machine supplied with a very weak solution of hydrochloric or sulphuric acid which decomposes the lime soaps and converts the lime into soluble salts which are removed by washing in water in a second washing machine.

The fatty matter which was combined with the lime remains on the cloth as free fatty acids but can be easily removed by the next process, called the *lye boil,* which consists in boiling the goods in a kier with soda ash and resin soap.

The soda ash readily combines with the free fatty acids present, forming soda soaps which are easily soluble in water and removed by passing the cloth through water in one of the usual washing machines. The kiers used for the lye boils are quite similar to those described above and are worked in the same manner, but owing to the fact that the soda compounds used are easily soluble in water a previous impregnation of the material is not necessary and the cloth is simply run into the hot liquor in the kier. This boil usually lasts several hours and needs about 2 per cent of soda ash and 1 per cent of resin, reckoned on the weight of the goods.

After this boil the liquor is run off and the cotton well washed in the kier.

This lye boil is frequently succeeded by a second boil with soda ash alone, the object of which is to remove any traces of resin which might remain in the goods and cause yellowish stains. In some cases resin is not used, but it has a very powerful cleansing action on certain impurities.

After another thorough wash with water the cotton should be quite clean and only have a slight tint owing to the natural colouring matter present which is removed by the bleaching operation proper. This operation which, as already explained, is not required if the cotton is to be dyed in dark shades, consists in submitting the cotton to the action of a dilute solution of bleaching powder. The usual name for this is *chemicking*.

The solution of bleaching powder or *chemick* is prepared by grinding the lumps of bleaching powder to a paste with water and diluting to the required extent. In practice the solution must not be more than 1·01 in specific gravity or there is great risk of tendering the cotton owing to the formation of oxy-cellulose.

The cloth is run into wooden or stone tanks fitted with false bottoms and the chemick solution is circulated through the goods by means of a centrifugal pump, which sucks up the liquor from an under tank and showers it over the surface of the goods through which it gradually sinks back to the tank beneath to be again circulated. This is kept working for one or two hours and the cloth is then well rinsed with water, after which a weak acid solution is circulated for some time in order to decompose the remaining chemick and to complete the bleaching action. At the same time this *white sour* converts the lime into a soluble form which can be washed out of the goods by a subsequent thorough wash with water in a washing machine.

In many cases the chemicking is carried out by simply running the cloth through the chemick solution in an ordinary washing machine and, after a good squeeze, allowing the cloth to lie for some hours in a heap or in wooden tanks to give time for the bleaching action. After washing with water the cloth is soured and again washed. It is most important that every trace of acid be removed from the cloth at this stage as, if any be left in, it would be liable to cause tendering of the cloth at later stages, especially if the cloth were submitted to a high temperature such as occurs when finishing with a heated calender.

The actual bleaching process is now completed and it only remains to pass the cloth through certain mechanical operations in order to obtain the fabric in a regular open form. The treatment *in the rope* naturally stretches the cloth considerably at the expense of its width and at the same time pulls the cloth out of shape so that one selvedge is frequently ahead of the other, and if it were finished in this condition it would cause trouble in use as owing to the irregularity of the weft threads it would not *hang* properly when made up into garments and if torn across would give a slanting tear instead of a straight one.

After a final wash the cloth is run through a special squeezing machine under considerable pressure in order to remove as much water as possible and so economize heat in the subsequent drying operation. The next stage is to untwist the rope of cloth and get it back into the open width This is carried out on a machine known as a *Scutcher* or *Opener* The rope of cloth is passed through suitable pot eyes and after running through the air for a distance of 30 ft or more comes in contact with a rapidly revolving beater which shakes the folds out of the cloth by its action, after which it passes through a pair of *scroll rollers*, covered with spiral grooves, which take out the remaining creases The cloth, now again in the open width, is then run to the drying apparatus which usually consists of a large number of horizontal copper cylinders which are heated internally by steam at a few pounds pressure The band of cloth passes round these heated cylinders which revolve on horizontal axes and is finally folded down at the exit end

In order to get back the original width of the cloth and straighten the selvedges the cloth is passed through machines known as *stenters* but this process really belongs to the finishing of the cloth and will not be dealt with here

It will be seen from the above description that to obtain a thorough bleach a very complicated process is necessary The various operations may, for convenience, be summarised as follows—

1 Marking,
2 Stitching,
3 Singeing (if necessary),
4 Steeping,
5 Lime Boil,
6 Lime Sour,
7 Lye Boil,
8 ,, ,, (second),
9 Chemick,
10. White Sour,

each of the chemical treatments being followed by a thorough wash with water, usually in a washing machine.

The *full bleach* for cotton cloth described in detail above is a very thorough one, and is employed in cases where it is desired to remove practically all traces of impurity from the cotton.

In one of the most important styles of calico printing the cloth is first printed with a *printing colour* containing salts of alum or iron, after which it passes through various operations which fix the mineral matter on the cloth in the desired pattern.

When this prepared cloth is dyed with suitable dyestuffs the latter are attracted and fixed on the cloth by the mineral matter or " mordant " so that a coloured pattern is obtained on a white ground. One of the most important dyes used for this process in former days was the vegetable dye known as Madder, so that the method was known as the *Madder style.* Unless the cloth used for this process is thoroughly clean the impurities present attract and fix mineral and colouring matters from the various baths through which it passes so that the " whites ". of the cloth become stained and the brilliancy of the finished print is impaired.

The full bleach described above was employed in order to obtain the necessary purity of the material so that it became known as the *Madder bleach,* and the name has stuck to it, although the dyestuff Madder has been replaced by other dyes.

The main peculiarity of the madder bleach is the use of the lime boil. At first sight it appears to be a waste of time to first convert the fatty matter present on the cloth into lime soaps which remain sticking to the cloth and have to be removed by further operations, and it would seem more reasonable to boil with soda lyes which would convert the fats into soluble soaps which only require a wash with water to remove them. However, practical bleachers still use the lime boil, especially in the bleaching of cloth for printing, and it appears to have a considerably more efficient cleansing action on some of the impurities present than the simpler soda process

The cotton bleacher has to deal with materials of the most varied description and has to modify his processes to suit the requirements of the different classes of goods.

In most cases, especially for cloth which is to be dyed in plain shades, this severe bleach with lime boiling is not required and at the present day a large proportion of the cotton cloth bleached has been given a considerably shorter process

For cotton cloth which is to be used in the white state (Market Whites) the lime boil is often omitted. The cloth is given a preliminary wash with water and sometimes soured to loosen some of the impurities, and after a thorough wash it is run into a kier and boiled for some hours with soda ash or caustic soda, to which some resin soap is frequently added

When the boiling is completed the cotton is well washed, first in the kier itself and then in a washing machine, and passed on to the usual chemicking and souring operations

If it is to be dyed in dark shades a simple boiling with soda is usually sufficient, the chemicking process being omitted

It is also advisable to omit this operation if the cloth is to be dyed with Turkey Red, as chemicked cloth is stated to give an inferior colour to that which has not been so treated

Most cotton piece goods can be bleached in the rope form, but with very thick, heavy goods such as moleskins, corduroys, etc , this is impossible, and they should be bleached in the open width Goods like those last mentioned, which are likely to contain large amounts of sizing materials, are often first treated with a solution of malt which converts any starchy matter present into soluble compounds which can be removed by a subsequent wash with water This preliminary treatment greatly facilitates the later processes through which the cloth has to pass

Perhaps the most troublesome class of material with which the bleacher has to deal is that containing coloured portions which must not be affected by the process used to bleach the white

This class includes such materials as shirtings, towels, handkerchiefs and the well-known "dhooties" (for India) which contain coloured threads in the form of stripes, borders, etc

These are usually woven along with *grey* cotton and the latter must be bleached white after weaving

The great difficulty is to carry this out without injuring the coloured threads, as very few cotton dyes will stand the full bleaching process described above

Speaking quite generally the ordinary process is modified by using open or low pressure kiers and avoiding the use of caustic soda Soda ash and soap are employed and the chemicking and souring solutions must be weaker than is usual with white cloth

Sometimes the coloured borders are hung outside the kier during the boiling process

CHAPTER VI

OTHER BLEACHING KIERS

ONE drawback which all the above mentioned kiers suffer from is the length of time needed to fill and empty them. The rope of cloth may be more than 10,000 yards long so that the operations of filling and emptying can easily take from one to two hours each, with the result that the kier may be out of action for a considerable proportion of the working day, thus necessitating a greater number of kiers to give the desired output than if the boiling process were a continuous one.

The really continuous processes will be dealt with later on but many attempts have been made to diminish the loss of time even when the intermittent method is employed.

One of the most successful is the *Mather kier* (made by Mather & Platt, Manchester), which is very widely employed.

The distinguishing feature of this kier is that the cloth is not run directly into the kier but is packed in special wagon-shaped containers which can be run into the kier on wheels after filling. In order to allow of this procedure, the kier is constructed in the form of a horizontal cylinder with an opening at one end through which the wagons can be run on rails. This end can be then completely closed by means of a wedge shaped door moved by suitable gearing. The kier is constructed in various sizes to hold from one to three tons of cloth and usually takes two wagons of cloth at a time. The wagons are open at the top and have a perforated false bottom to allow of the passage of the liquor.

The rope of cloth is usually impregnated with the scouring liquor before filling it into the wagons and the latter are then run into the kier and the door tightly

"MATHER" KIER

closed. The kier is then partly filled with more scouring liquor and the air present is removed by means of steam or a vacuum pump.

The circulation of the liquid is effected by means of

a centrifugal pump which sucks the liquor, through suitably arranged pipes, from under the false bottoms of the wagons and forces it up a pipe which showers it over the surface of the cotton in the wagons. The liquor then sinks through the cotton to be again sucked up by the pump. The heating of the liquor is done either by means of steam pipes placed along the bottom of the kier or else by an external heater through which the liquor circulates during its passage from the pump to the spraying device.

When the boiling is complete, the liquor is run off and the cotton washed with water in the kier itself by means of the pump, an arrangement being often fitted by which the direction of the circulation can be reversed.

There is considerable economy in time when using this kier, due to the fact that whilst one batch of cotton is being boiled the wagons from a previous boiling can be emptied and refilled ready to run into the kier. The whole operation of opening the kier, running out the wagons of already boiled cotton, running in fresh wagons and closing the door again, is stated to take about 10 minutes, as compared with the two or more hours needed with the usual vertical kiers. A steam pressure of about 40 lb. is employed and, owing to the comparatively shallow layer of cotton in the trucks, the circulation is said to be more regular than is the case with ordinary kiers in which the cloth is packed in deeper layers.

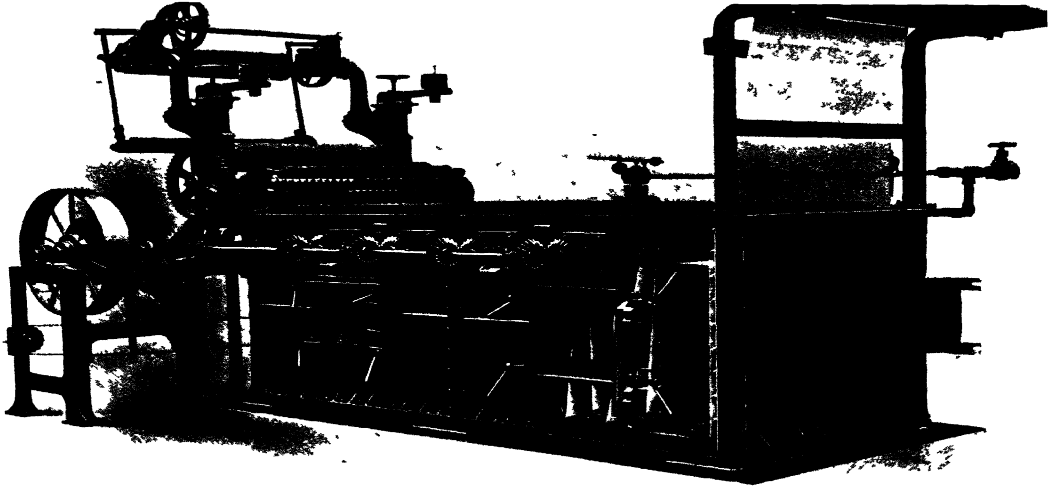
This kier is chiefly used for the lye boils with soda.

In all the kiers so far described the cloth is bleached in the rope form so that the liquids employed have to penetrate a considerable thickness of more or less tightly twisted cloth. It is evident that the circulating liquor will not meet with equal resistance in all parts of this mass of material and, as the liquor will always tend to take the path of least resistance, some of the cloth will undergo a more thorough treatment than the rest, thus causing uneven bleaching.

Of course, the ideal method would be to treat the cloth throughout in the open width so that the resistance to penetration would be reduced to a minimum, but there are considerable difficulties to be overcome if this method be attempted with high pressure kiers.

As an example of the application of this principle the *Jackson kier* may be taken. The kier itself is a horizontal cylinder fitted with a door at one end so that a framework carrying the cloth can be run in on a trolley. The cloth, having been thoroughly impregnated with caustic soda solution, is tightly wound in the open width on a *batching roller* and placed on the framework mentioned above. This frame carries another roller and during the boiling process the cloth is unrolled from the first roller and wound on the second, the winding mechanism being automatically reversed at suitable intervals. A third roller rests on the cloth and keeps the rolls smooth, at the same time helping to squeeze the liquor into the cotton. The trolley with the batch of cloth having been run into the kier, the door of the latter is shut and caustic liquor is run in by means of a pump and circulated so that it falls in a shower on the cloth as it is being transferred from one roller to the other. The liquor is heated by steam at about 40 lb. pressure and the boiling is continued for about two hours whilst the cloth is run continuously to and fro between the rollers. About 2,000 yards of cloth can be boiled in one batch and the subsequent chemicking and souring operations are carried out by similar arrangements.

This kier allows high pressure boiling to be employed thus differing from most open width kiers, which only work at quite low pressures.



CONTINUOUS BLEACHING KIER (OPEN WIDTH)
(A. Edmeston & Sons, Ltd., Patricroft, Manchester)

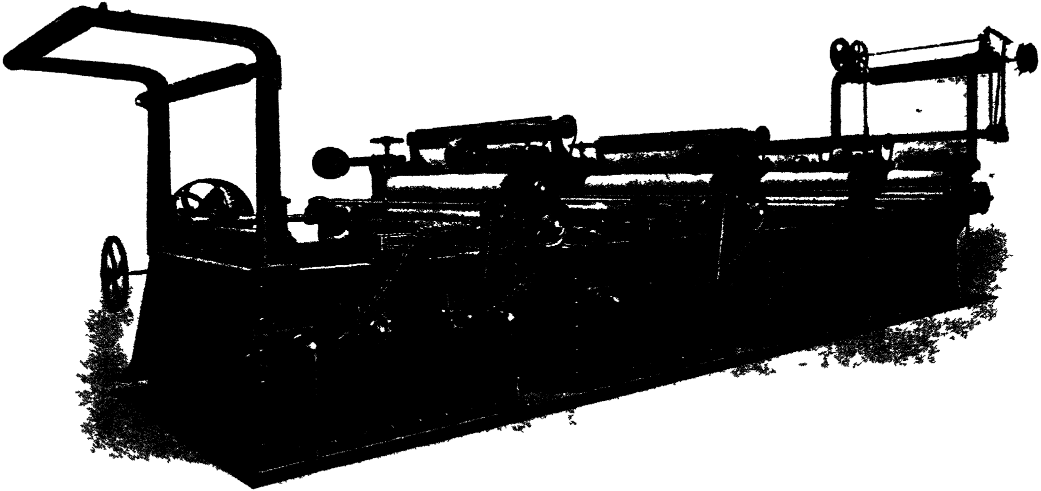
Continuous Kiers. The introduction of kiers of the Mather and Jackson types has resulted in a great saving of time in charging and emptying compared with the vertical type of kier, but in some recent kiers this loss has been entirely eliminated by making the process a continuous one so that the cloth passes through the kier in an unbroken band.

One of the most successful kiers of this character is that constructed by Messrs. Edmeston & Sons, Patricroft, which can be used for cloth either in the rope form or in the open width. The essential point about this kier is that the cotton is treated alternately with boiling liquor and steam, which have a very efficient action in removing impurities.

The construction of this kier is shown in the illustrations. It consists of a rectangular iron tank which is completely closed at the top with the exception of a small portion at each end which serves for the entrance and exit of the cloth. A vertical iron partition extends downwards at each end of the covered-in portion so as to dip beneath the surface of the scouring liquor which is run into the lower portion of the tank. The result is, that the portion of the kier between these two partitions is shut off from all contact with the external air by means of the liquid seal formed by the partition plates and the liquid in the kier.

The liquor in the kier is kept boiling by means of steam coils, and any air in the central closed portion is blown out of the kier by the steam through suitable valves.

The band of cloth in the open width enters the kier at one end through the opening referred to above and passes under the partition plate over suitable guide rollers into the closed central compartment, in which it circulates up and down over a number of rollers before finally

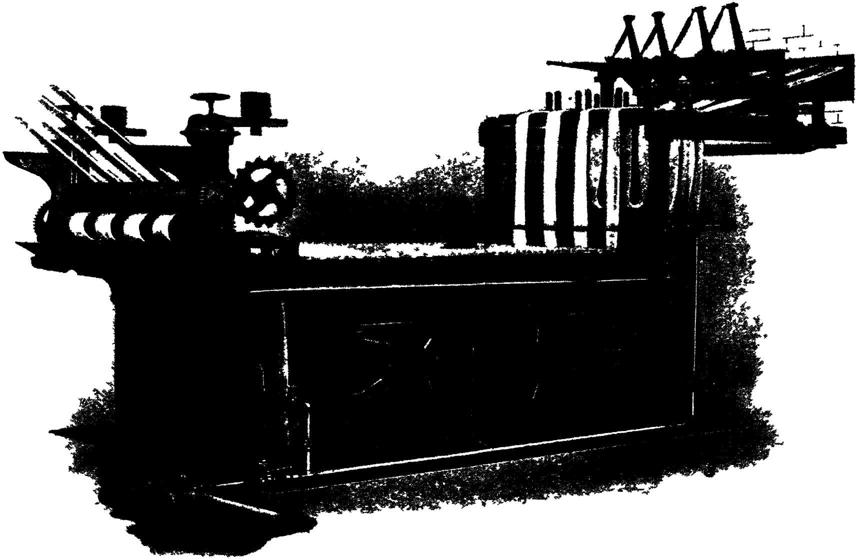


FOUR-TANK OPEN WASHER
(A Edmeston & Sons, Ltd , Patricroft, Manchester)

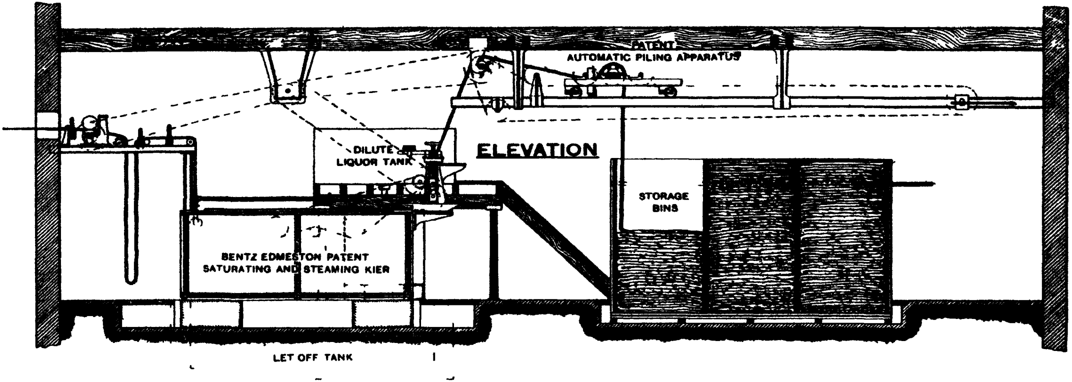
emerging from the kier by passing under the other partition. A small pressure of steam is kept up in the inner compartment so that the level of the liquor in this is slightly depressed and that in the end portions slightly raised. The pressure possible depends upon the height of the columns of liquor in the end sections of the tank and is, therefore, usually only a few pounds to the square inch. During its passage through the kier, the cloth is submitted to alternate treatments with boiling scouring liquor and with steam under slight pressure, and owing to the open condition of the material, a very satisfactory cleansing action results. If the cotton is to be boiled in the rope form, four ropes of cloth can be run through the kier side by side. The running speed depends on the thickness and character of the cloth ; it varies from 30–50 yards per minute.

For use with the above kier, the same makers supply a special open width washing, chemicking and souring machine which is shown in the figures. After emerging from the kier, the cloth, which has been well squeezed, is piled down in wooden storage bins and left for some hours in order to complete the action of the caustic lye, after which it is run through the continuous machine shown. It passes first through two washing boxes fitted with spraying pipes, squeezing rollers, etc., and then into a third tank containing the chemick solution. After squeezing and piling it is again washed and then soured on a similar machine followed by a final wash with water.

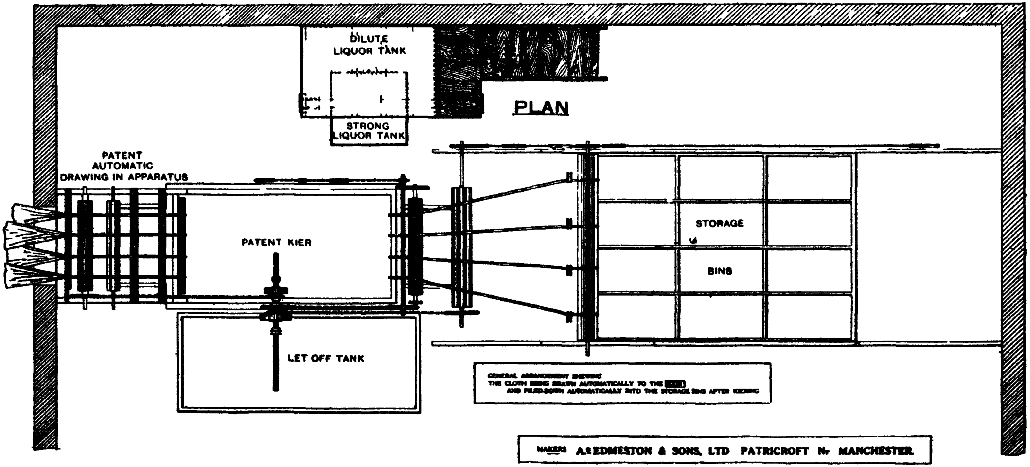
If the kier is to be employed for cloth in the rope form a special *piling* arrangement is supplied (as illustrated) which automatically piles down the different ropes of cloth into separate storage bins so that there is no risk of the various ropes becoming entangled when they are withdrawn from the bins for further treatment.



CONTINUOUS BLEACHING KIER (ROPE FORM)
(A Edmeston & Sons, Ltd , Patricroft, Manchester)


PATENT
AUTOMATIC PILING APPARATUS
ELEVATION
DILUTE LIQUOR TANK
STORAGE BINS
BENTZ EDMESTON PATENT SATURATING AND STEAMING KIER
LET OFF TANK

CONTINUOUS KIER (ELEVATION)
(A Edmeston & Sons, Ltd , Patricroft, Manchester)


DILUTE LIQUOR TANK
PLAN
STRONG LIQUOR TANK
PATENT AUTOMATIC DRAWING IN APPARATUS
PATENT KIER
STORAGE
BINS
LET OFF TANK
GENERAL ARRANGEMENT SHEWING
THE CLOTH BEING DRAWN AUTOMATICALLY TO THE [illegible]
AND PILED-DOWN AUTOMATICALLY INTO THE STORAGE BINS AFTER KIERING
MAKERS A. & EDMESTON & SONS, LTD PATRICROFT Nr MANCHESTER

CONTINUOUS KIER (PLAN)

This kier is usually employed with the caustic soda boil in which case the operations are as follows—

1. Boil in kier with soda solution.
2. Wash.
3. Chemick.
4. Wash.
5. Sour.
6. Wash.

If it is desired to use the lime boil the above series of operation are preceeded by—

(*a*) Boil in kier with lime water.
(*b*) Wash.
(*c*) Sour.
(*d*) Wash.

Most cotton cloth can be bleached in the rope form, but heavy materials which are too thick for that process are better bleached in the open width, although, of course, the production per day is less than when four ropes of cloth are running through the machine simultaneously.

The results obtained with this kier are stated to be perfectly satisfactory.

Cotton Yarn Bleaching. This comes next in importance to the bleaching of cotton cloth. Cotton is bleached in this form if it is to be used as sewing cotton or thread either in the "white" or else dyed in pale or bright colours. Yarns, which are to be employed in weaving materials with coloured stripes or patterns, must usually be bleached to a greater or less extent preparatory to dyeing.

Cotton yarn may be bleached in several different forms; the most important method is to bleach it in the form of hanks but a large amount is also done in the warp. A small proportion is also bleached whilst wound on bobbins or spindles in the forms known as cops or cheeses.

Hank Bleaching. A full bleach usually comprises a kier boil with soda ash or caustic soda followed by a thorough wash with water, after which the yarn is chemicked and soured

The boil is carried out in low or high pressure kiers in which the yarn is packed as evenly as possible in order to get an equal circulation of the liquor, and the washing is usually effected on special washing machines in which the hanks of yarn are revolved on reels in a current of water The chemicking and souring is carried out in cisterns through which the chemicking, souring and washing liquids are circulated by means of a pump.

In order to save labour the hanks are sometimes looped or joined together so as to form a long rope and this is then passed through the various operations in a similar manner to that employed for cloth in the rope form.

Warp Bleaching. There are several methods for bleaching cotton yarn in the warp form As already explained the warp of a cloth consists of those threads which run lengthwise in the cloth The warp may contain hundreds of distinct threads which are carefully wound on the warp *beam* and placed in the loom One end of each thread is unwound and stretched out by suitable means so that a layer of parallel threads is obtained equal in width to the cloth to be woven The shuttles containing the cross or *weft* threads move backwards and forwards under and over these threads and the interlacing of these two sets of threads forms the cloth

In order to facilitate the previous bleaching or dyeing of these warp threads they are frequently collected together so as to form a long rope of more or less parallel threads The number of individual threads and the length of the rope depends of course on the dimensions of the cloth which is to be woven, but the total length of the rope may be several thousand yards. To render this easier to work it is often chain linked by a special machine which shortens its length considerably.

This chain is then carefully packed into a kier and boiled with soda ash or caustic soda in the usual manner, after which it is run out into cisterns and submitted to the chemicking, souring and washing operations as described for cotton yarn.

Another method employed is to run the rope of threads, in unlinked condition, through a number of tanks fitted with suitable guiding and squeezing rollers, in which the warps are treated with the various chemical solutions.

Loose Cotton Bleaching. Cotton is seldom bleached in the loose condition. For one thing, the later manufacturing operations through which it has usually to pass would soil it considerably, so that the previous bleaching would be largely wasted.

The chief object of bleaching cotton in this form is for the production of absorbent cotton for surgical purposes and for waddings of various kinds, such as are used in jeweller's boxes. A small amount is also bleached in this form in order that it may be spun along with other fibres, such as wool, for the production of mixed yarns.

The main trouble in bleaching this class of material is the ease with which it becomes entangled together, so causing considerable waste in the later operations.

To avoid this as much as possible, the cotton is not allowed to be agitated by violent boiling, and the ordinary boiling process is frequently replaced by a simple steep in the hot liquids.

For surgical purposes the main object is to obtain a very absorbent material and the bleaching is carried to extreme lengths with little regard to the strength of the material.

The loose cotton can also be packed in closed receptacles and the various bleaching liquids circulated through it by means of a pump. In this process there is practically no risk of the material becoming entangled.

CHAPTER VII

THE BLEACHING OF LINEN AND THE MINOR VEGETABLE FIBRES

Linen Bleaching. As previously mentioned, raw linen contains a great deal more impurity than raw cotton, the total amount present sometimes exceeding 30 per cent of the weight as compared with approximately 5 per cent in the case of cotton. This large amount of impurities appears to consist principally of the gummy matter which binds the individual flax fibres together.

Owing to the large proportion of non-cellulose matter present, the bleaching of linen is a much more laborious process than that of cotton, and it is rendered more difficult by the fact that the linen fibre is more sensitive to chemicals than the cotton one. This is probably partly due to the fact that the fibre, as spun, is not a simple one like cotton, but consists, in reality, of a large number of short fibres of about the same dimensions as cotton fibres, which are tightly gummed together by the gummy binding material present.

If the chemical treatment is too severe it is liable to break up these compound fibres into their short constituent parts so that the material loses considerably in strength. It is a well known fact that the more thoroughly linen is bleached the weaker it becomes.

Owing to the above reasons, the linen bleacher is unable to employ strong chemical solutions, and in order to obtain a satisfactory result with weak solutions the operations have frequently to be repeated several times.

The old method of linen bleaching has already been described when dealing with the historical development of the subject. Owing to the mild chemical treatment and the large dependence on the bleaching action of light, the material lost very little of its strength during the process, but owing to the excessive time required the output was very small and quite insufficient for present day conditions.

The bleaching of linen, as carried out at the present day, is very similar in its main operations to that employed for cotton, but the actual processes have to be considerably modified on account of the much larger amount of impurity present and the different structure of the fibre.

Linen Yarn Bleaching. There are four distinct degrees of linen yarn bleaching recognised in the trade, which are known as the quarter, half, three-quarter, and full bleach respectively. The half bleached yarn is practically clean but still contains a little colouring matter which gives it a " cream " tint.

The yarn is first boiled for some hours in a high or low pressure kier with a solution of soda ash and then well washed with water. The next operation is the chemicking, which is carried out in a different manner than with cotton yarn. A very weak solution of bleaching powder is used, and instead of allowing the yarn to lie in the chemicking tank, the hanks are suspended on reels so that they can be revolved in the liquor. A wash, sour with dilute acid, and another wash follow, after which the yarn is again boiled or " scalded " with soda ash solution previous to a second chemick and sour.

These boiling, chemicking and souring operations are repeated one or more times according to the degree of bleaching required, the yarn being, of course, thoroughly washed between each operation.

In some cases the yarn is spread on the fields and exposed to the action of the weather for a week or more after some of the "scalds." This is called *grassing* and is peculiar to linen bleaching.

Linen yarn which is to be dyed in dark shades simply requires to be boiled out with soda ash and washed with water.

Yarn which is to be woven into fine cloth should be given a partial bleach before weaving as it facilitates the weaving process.

Linen Cloth Bleaching. Linen cloth contains, of course, all the impurities which were present in the yarn before weaving, and therefore, unless the material was bleached "in the yarn," it contains the natural impurities of the linen together with any sizes used in dressing the warps.

The method of bleaching employed is very similar to the Madder bleach used for cotton cloth. The cloth is boiled in kiers with lime or soda and thoroughly washed and also soured if lime has been used. The subsequent processes are of the same kind as those mentioned for linen yarn and consist of repeated soda boils, chemicks and sours with periods of exposure on the grass.

The washes which are given between each of the above operations are carried out in the usual washing machines or else in *washing stocks*, in which the bundles of cloth are placed in a specially constructed receptacle and submitted to the pounding action of large wooden fallers or hammers, while a current of water is run through. The hammers are raised alternately by a system of cams, and, by means of their pounding action, drive the water right into the interior of the material and effectively remove any soluble or loose impurities.

In order to remove the black or brown woody particles or *sprits* which are usually present in the cloth, the latter is passed through a soap solution and then between two heavy fluted boards, one of which moves to and fro over the other, so that they exert a rubbing action on the cloth. These are known as *rubbing boards*.

Minor Vegetable Fibres. The minor vegetable fibres such as hemp and jute are seldom bleached.

Hemp is chiefly employed in its natural colour for the manufacture of ropes, cords and twines and is very seldom dyed, but if pale shades are required it can be first treated with a weak solution of silicate of soda or water-glass and then weakly chemicked and soured.

Jute is very sensitive to bleaching solutions. The individual jute fibres are only about ⅛ in. in length so that, if the compound fibre be split up into its constituent cells, the material becomes very weak and practically useless.

For most purposes it is simply boiled with water or with soda ash solution, but if a very light fibre is needed the boiled jute is sometimes stoved with the vapour of burning sulphur in a similar manner to wool.

It is so sensitive to chlorine compounds that they can only be employed with the greatest care.

China grass or ramie comes into the market very white and only needs a boil with soda.

Many of the less used vegetable fibres are sometimes bleached to some extent, but they are of small importance and will not be dealt with here.

Bleaching of Artificial Silk. As previously mentioned, artificial silk consists usually of practically pure cellulose.

Owing to its method of manufacture it is usually free from any injurious impurities and only requires to be bleached for pale shades or white.

This bleaching may be done with ordinary bleaching powder solutions, but it is much preferable to use a solution of hypochlorite of soda prepared by the electrolytic method.

The silk is soaked in a dilute solution of this substance for a short time, rinsed with water, slightly soured with acid and again well rinsed. The process can be finished by a treatment in a fairly strong soap solution and a final rinse.

Owing to the great loss of strength which artificial silk suffers when it is wetted, it must be very carefully handled whilst it is in that condition. Fortunately, it recovers its original strength on drying.

CHAPTER VIII

THE BLEACHING OF ANIMAL FIBRES

ALTHOUGH the various kinds of natural silk belong to the class of animal fibres just as much as the different hairs and wools, yet the impurities present in the latter fibres are so different to those found in silk that it is much more convenient to treat the methods employed in their purification quite separately.

As previously mentioned, the hairs and wools of a large number of animals are employed in textile manufacture; but the wool of the domestic sheep far surpasses in importance all the other hair and wool fibres combined, and will therefore be taken as an example in the following description of the various processes used in purifying these fibres.

Impurities Present in Raw Wool. During its growth on the sheep's back, the wool fibre becomes laden with impurities of various kinds, some of them being secreted by the animal itself whilst the others are picked up from external sources. The amount of these impurities is often very large and, in some cases, the raw wool contains as little as 30 per cent of pure wool fibre. Speaking generally, the finer varieties, such as Merino, usually contain the greatest proportion of impurities and yield on the average about 50 per cent of fibre, while the longer, coarser, lustre wools may yield as much as 80 per cent.

The bulk of the imported wool comes to this country *in the grease,* as it is cut from the sheep's back, it being found that the wool keeps in better condition during transit and is less liable to *mildew* if it is sent in this form than if it has been previously cleaned. In some cases it has been *fleece washed* before shearing in order to remove the rougher dirt and a considerable quantity is *scoured* before shipment to save carriage. Besides the wool sheared from the living sheep, the dead meat trade yields a large amount of *skin wool* which is removed from the skins of the sheep after slaughter. In some cases the skins are treated to a *sweating* process, or with certain chemicals such as sulphide of soda, in order to loosen the fibre so that it can be easily pulled out by hand, and the product thus obtained is of pretty good quality. In many cases, however, lime is used to loosen the fibres and the *slipe wool* obtained is very troublesome to the manufacturer, as the lime it contains not only interferes with the various processes but deteriorates the fibre, making it brittle and weak.

The impurities likely to be present in raw wool are of a very varied character but may be classified as follows for practical purposes—

1. THE WOOL FAT. This is a complex mixture of bodies of a fatty or waxy nature containing free fatty acids and being insoluble in water. This substance is secreted by oil glands in the skin of the sheep and forms the natural lubricant of the wool fibre. It helps to keep the wool soft and pliable and at the same time tends to prevent the individual fibres in the fleece becoming tightly matted together on the sheep's back.

2. WOOL PERSPIRATION. This consists of a mixture of substances which are soluble in water and are mainly the potash salts of various fatty acids. They are very similar in composition to ordinary soft soap and have considerable cleansing properties, so that they are of assistance in the cleansing of the wool. They are secreted by the sudatory or sweat glands of the sheep and the mixture is often known by its French name "Suint."

3. Mechanically Adhering Impurities. These consist of sand, earth and dirt of various kinds picked up by the wool during its growth on the sheep or in its transit to the manufacturer. A very common impurity, which often causes considerable trouble during manufacture, is vegetable matter, such as grass, prickly seeds or *burrs*, etc., which become entangled in the fleeces whilst the sheep are grazing.

4. The Natural Colouring Matter in the Wool. Ordinary wool is usually a pale yellowish white, but grey, black and brown varieties are known.

Raw wool, being such an impure material, requires to be purified to a considerable extent before it can be satisfactorily employed in manufacture. The removal of the wool fat, wool perspiration and dirt is usually effected by the process known as *wool scouring*, the term bleaching, as applied to wool and other animal fibres, being restricted to the actual removal of the natural colouring matters present.

The impurities present in the less important textile wools and hairs, e.g. mohair, camel hair, horse hair, etc., are of the same general character to those present in sheep's wool although the amount of impurity present varies very much in different samples.

Wool Bleaching: Historical. The actual processes employed in scouring and bleaching wool have undergone very little change in principle for many centuries.

The chief changes have been on the mechanical side, with the object of dealing with large quantities of material and improving the quality and output of the finished product.

One of the oldest scouring methods made use of the substance known as *lant* as a scouring agent. This substance was in reality urine which had been allowed to become slightly putrid and probably owed its cleansing properties to the presence of carbonate of ammonia produced during its putrefaction.

The wool was worked for some time in a warm mixture consisting of one part of putrid urine mixed with 4 or 5 parts of warm water. After this steeping process was completed, the wool was lifted out of the liquid and allowed to drain and then placed in running water until the latter came away quite clean. This part of the process was usually carried out by placing the wool in baskets and immersing the latter in a running stream or river. This method is still used in some countries and was even employed in small works in this country not many years ago, but, although it gives quite good results, could not of course be employed for scouring on the enormous scale at present practised, to say nothing of the objectionable character of the material used.

The other main method for wool scouring consisted in treating it with soap solutions. The manufacture of soap appears to have been known for more than a thousand years, being probably first effected by boiling various oils with solutions of wood ashes.

Even the chief method at present in use for the actual bleaching of wool, namely, by submitting it to the fumes produced by burning sulphur, has been practised for many centuries, and the only important change has been the introduction of the oxidation bleach with hydrogen peroxide.

CHAPTER IX

WOOL SCOURING

As already mentioned, the chief impurities present in raw wool consist of wool fat, wool perspiration and adhering dirt of various kinds. The wool perspiration, being soluble in water, can be largely removed by simply steeping the wool in warm water, but this treatment has very little effect on the wool grease as the latter is insoluble. The adhering dirt is largely embedded in the wool grease and cannot be properly removed unless the wool fat itself is removed.

There are two main methods employed at the present day for cleansing wool: (1) the emulsion method; (2) the solvent method. The emulsion method consists essentially in treating the greasy wool with soap solutions, the cleansing action of which is identical with that which takes place when we employ soap to remove grease from our hands. The second cleansing method depends on the fact that the wool fat, although insoluble in water, can be readily dissolved by various organic liquids, such as benzine or petrol, and can be removed in this manner from the wool by a process very similar in principle to that employed in the dry cleaning of soiled clothing. This solvent method has very considerable difficulties to contend with and is of much less practical importance than the emulsion process which will be dealt with first.

The mechanism of the emulsion process will perhaps be easier understood if one of the commonest examples of an emulsion, namely, ordinary cow's milk, be first considered. If a drop of milk be examined under the microscope it will be seen to consist of a number of minute drops of oil (butter fat) floating in a practically colourless liquid. Milk, in fact, is an emulsion of milk fat in a watery solution containing the casein and milk sugar, and owes its opaque yellowish-white colour to the presence of innumerable minute drops of oil floating in the watery fluid. On standing for some time the milk emulsion tends to break up and the lighter fat drops rise to the surface forming the usual layer of cream and having below it a much more transparent layer of skim milk. This separation can be made much more complete by passing the milk through a centrifugal cream separator.

Soap solutions have very strong emulsifying powers. If a little olive oil be well shaken in a bottle with a quantity of water the oil breaks up into very small drops which are dispersed through the water, but if the shaking be stopped, these minute drops of oil soon coalesce together and rise to the surface, as the emulsion of olive oil in water is much less permanent than that of milk described above. If, however, in the above experiment, some soap solution be added to the water before shaking it with the oil, it will be found that the emulsion formed is much more stable and that the oil only separates out at the surface very gradually.

The scientific explanation of the action of soap in scouring is very complicated but, put in simple language, the process appears to be something like the following—The soap solution at once wets the greasy material and comes into intimate contact with the layer of grease, which it breaks up into minute drops which form an emulsion with the soap solution. Owing to the stable character of this emulsion, these minute oil drops separate very slowly from the emulsion with the soap, thus allowing time for the removal of the emulsion from the material by means of fresh soap solution, squeezing, etc. Most of the dirt becomes loosened by the removal of the greasy binding material and is either carried away in suspension in the soap solution or else sinks to the bottom of the vessel out of contact with the floating wool.

The wool perspiration, as already mentioned, is a form of soap, and, owing to its presence throughout the wool, plays a considerable part in the scouring process.

The wool fat itself contains a certain proportion of free fatty acids which can combine with alkalies such as soda or potash to form soaps, and in some works, especially on the Continent, advantage is taken of this fact in order to economize soap. The raw wool is treated with a warm solution of an alkali which at once combines with the free fatty acids present to form a soap which then exerts the usual scouring action on the wool.

Wool Scouring: Practical. The usual method of scouring raw wool on the large scale is to treat it in a succession of two or more soap baths until it is quite clean. If only a single bath was used, the wool, on removal from the bath, would be saturated with the dirty soap solution and retain some of the dirt, whilst by the method employed in practice the wool is well squeezed by means of rollers between each soap bath so as to remove as much dirty liquor as possible before passing it into the next bath which contains a cleaner soap solution. The result is that most of the impurities have been removed before the wool enters the last soap bath and any liquor left in the wool after passing through this contains very little impurity.

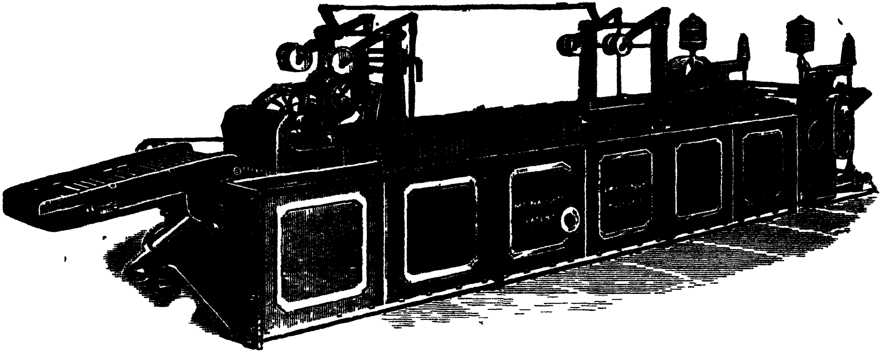
In order to remove the insoluble dirt of various kinds that is present in the wool a certain amount of agitation is necessary, but the greatest care must be taken to avoid too violent movement, especially with fine wools such as merino, which are very easily matted or felted together with the result that there is considerable loss and breakage of the wool fibre in the subsequent manufacturing operations.

On the quite small scale, the necessary agitation is effected by stirring the wool by hand with wooden poles, but on the large scale, the process of scouring is carried out by a continuous process, the wool being passed, by mechanical means, through a succession of soap baths so that the agitation is under regular control.

The following description of a wool scouring machine manufactured by McNaught of Rochdale may be taken as a typical example.

It consists essentially of a rectangular iron tank varying in length from 12 ft. to 36 ft. and being about 3 ft. 6 in. in width and 3 ft. in depth. This tank contains the liquor to be used for scouring and has a sloping bottom so that any heavy impurities such as sand, etc., tend to collect at one side, from which they can be removed at intervals through a cleansing outlet controlled by a valve.

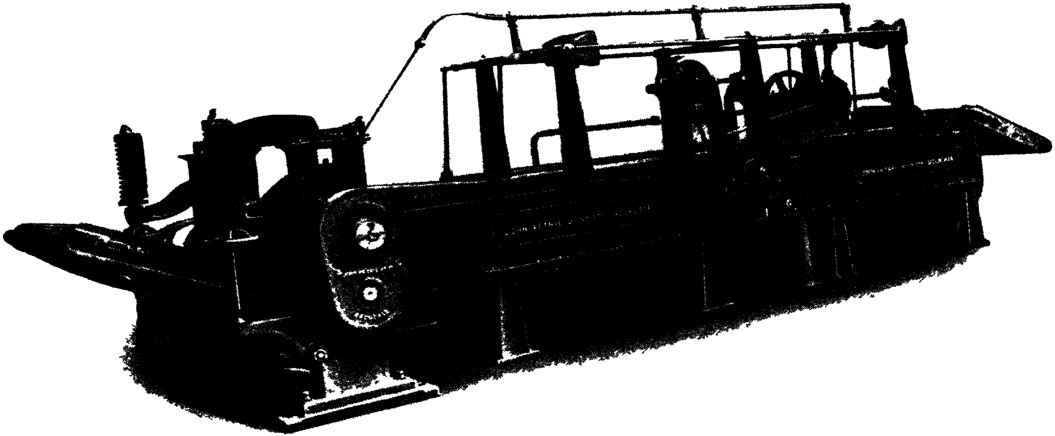
The wool itself is not placed directly in this tank but in a shallow trough about 2 ft. wide and 1 ft. deep, which runs along the upper portion of the large tank and is kept partially filled with scouring liquor from the latter by having a perforated bottom. The wool is passed along this shallow trough by means of a suitable propelling mechanism, and any heavy dirt removed from the wool falls through the perforations in the false bottom and sinks into the large tank, being thus removed from further contact with the wool which is being scoured. The tank is charged with scouring liquor heated up to the correct temperature by suitable means, and the raw wool is fed continuously into the trough at one end by means of a travelling lattice, being pressed beneath the surface of the liquor by a special immersing arrangement.



" HARROW " WOOL WASHING MACHINE
(McNaught, Rochdale)

The method employed to propel the wool along the trough varies with the quality of the wool being scoured. For fine wools, which are easily felted by agitation, the *swing harrow* mechanism is used. This consists of a framework fitted with spikes similar to a harrow. The frame being lifted out of the trough at the forward end, takes a stroke backwards above the surface of the liquid and then sinking down so that the spikes are immersed in the trough, moves slowly forward a short distance, thus moving the wool forward towards the delivery end of the machine. The harrow is then raised out of the liquor and the too and fro motion repeated continuously. After a few strokes, the gentle movement of the liquor caused by the harrow practically floats the wool along so that there is very little actual mechanical stress between the wool and the spikes and the felting of the wool is reduced to a minimum.

For coarse wools, which are much less liable to become entangled, a more energetic movement can be employed, thus effecting a more rapid cleansing. In this case the *swing harrow* arrangement is replaced by the *swing rake*, in which the propulsion is effected by a number of independent swinging forks which have a much more severe agitating action. The delivery end of the trough is sloped up to a pair of heavy squeezing rollers, the upper one of which is well wrapped with some elastic material such as wool-top, cloth or india-rubber. The wool is practically floated into the nip between these rollers which squeeze out the dirty scouring liquor very effectively. The partially scoured wool passes from the squeezing rollers of the first machine into the trough of a second machine of similar construction to the first but usually rather shorter in length. In this machine, a second scouring treatment is carried out, but, as the wool has already been partially cleansed before reaching



SELF-CLEANING WOOL WASHING MACHINE
(Petrie & McNaught, Rochdale)

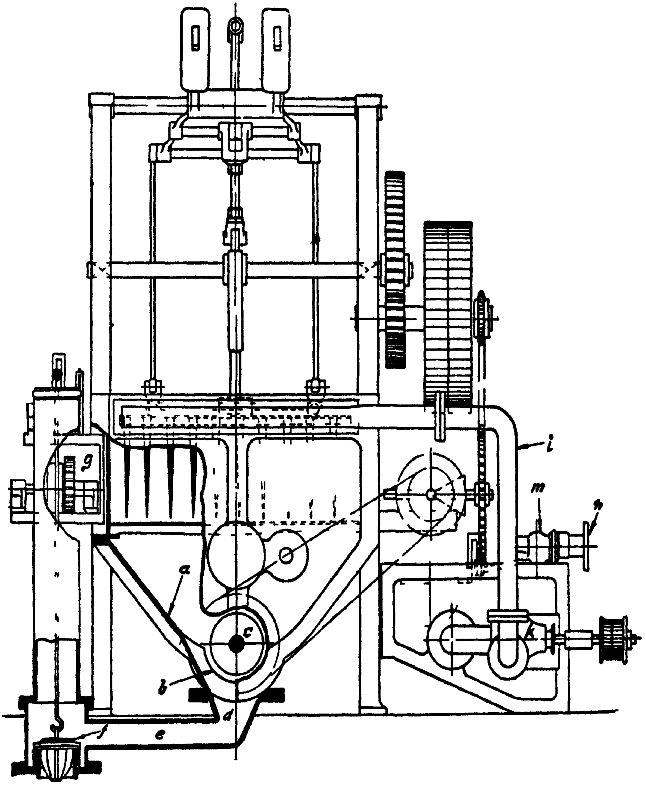
this bath, the scouring liquor is cleaner than that used in the first machine. Usually four tanks or *bowls* are employed in succession, the last one being charged with a weak soap solution or sometimes simply with water.

In order to economize materials, the liquors are used continuously until they become too laden with impurities to scour efficiently. Starting with all the bowls filled with clean scouring liquors the first bowl in the series naturally becomes exhausted first, and when this happens the dirty liquor is run off and the liquor from the second tank, which is naturally cleaner, is pumped in to take its place. Bowl number two is filled from number three and so on, the last being charged with fresh scouring liquor.

The dirty liquor expressed by the squeezing rollers is run into a settling tank and after a time the heavy dirt settles to the bottom whilst the lighter greasy portion rises to the top leaving a middle portion of fairly clean scouring liquor which is sucked out by means of a pump, warmed with steam, and run back to the scouring tanks. The first bowl should be kept at a temperature of about 125° F. but the others are best kept at a lower temperature, say 105° to 110° F., as the partially purified wool is more sensitive to hot alkaline solutions than the very greasy material.

Messrs. Petrie & McNaught have recently introduced an improved form of this machine which has many advantages. In order to obviate the numerous stoppages needed for cleaning out the dirt and grease which accumulate in the scouring bowls of the ordinary machines the improved form has a specially designed bowl as shown in the annexed diagram.

The upper part of the bowl, in which the wool travels, is separated from the lower portion by the usual perforated plates; the lower portion (*a*) is semi-circular



SELF-CLEANING WOOL WASHING MACHINE (SECTION)
(Petrie & McNaught)

in section and has a small semi-circular trough (*b*) running along it The dirt which falls through the perforated plates gradually collects in the central trough (*b*) and is then carried by a spiral screw conveyor (*c*) to a central hopper (*d*) The bottom of this hopper is connected by a pipe (*e*) to an outlet valve (*f*) which is automatically opened at arranged intervals in order to allow the accumulated dirt to escape from the hopper The dirtier the wool, the more frequently must this valve be opened

The liquor expressed from the wool by the squeezing rollers is run into a side tank, also shown on the diagram, and is continuously removed from the tank by the centrifugal pump (*k*) which delivers it back to the washing bowl by the pipe (*i*) In order to make up for the loss of liquor from the dirt outlet valve a ball-cock arrangement is fitted which admits liquor from the next following bowl or other source, and the pump is so adjusted that the level of the liquor in the main bowl is kept constant. This machine can be worked continuously, as the dirt and spent liquor are being removed and fresh liquor supplied during the whole period of operation

The composition of the scouring baths depends largely on the particular wool being scoured A pure soap is the most satisfactory scouring agent, so far as any injurious action on the wool fibre is concerned, but it is customary to strengthen its action by the addition of some alkali such as potash or soda The best results are obtained with a good potash soap and potassium carbonate but the cheaper soda soaps and sodium carbonate or soda ash are frequently employed, especially for the coarser qualities of wool

The first bowl is usually prepared with stronger solutions than the others. The soap and alkali should be dissolved in separate tanks and added to the bowls as required together with sufficient warm water to keep up the level of the liquor.

The great thing to be avoided in wool scouring is the presence of caustic alkali, either in the soap or alkali used, as this has a very injurious action on the wool fibre.

Slipe wools, which contain lime, cause great trouble in the scouring as the lime combines with the soap to form insoluble lime soaps which stick to the wool and are very difficult to remove. It is best to first treat such wools in a weak solution of hydrochloric acid which converts the lime into a soluble salt which can then be washed out with water. This treatment can be carried out in similar machines to those described above but they must be constructed of wood or other acid resistant materials.

The scouring machines mentioned above will scour from 1,000 to 2,000 lb. of wool a day according to the quality and the amount of dirt present.

Wool Steeping. As mentioned previously, the wool perspiration is soluble in water and can therefore be largely removed by simply steeping the raw wool in warm water before removing the wool grease and other dirt by the usual scouring process. This method of treatment is largely employed on the Continent as it is possible by this method to recover a considerable proportion of the potash which is present in the wool perspiration and has a considerable commercial value.

Not only is the bulk of the perspiration removed by steeping the wool in water but also a portion of the mechanically held dirt, so that when the subsequent soap scouring is carried out the baths keep clean much longer and a considerable economy of soap is effected. Notwithstanding the above considerations, the steeping process is not very largely employed in this country. For one thing the wool perspiration is a kind of soap and it is thought that it should be left in the wool to help the scouring process proper.

If the water be used at a comparatively low temperature only a small proportion of the grease is removed and, after allowing the heavy dirt to settle, the liquor is practically a solution of potash salts, from which the potash can be easily recovered by evaporating the water and burning off the organic matter from the residue, leaving an impure carbonate of potash.

The most expensive part of this process is the evaporation of the water for the recovery of the potash salts, so that the process is arranged to work with as little water as possible by using a somewhat similar principle to that employed in ordinary wool scouring.

This system of treatment, which is known as the *counter-current* method, consists essentially in treating the wool with successive quantities of water in such a manner that the raw wool is first treated with water which has already been employed for extracting previous quantities of wool and is almost saturated with potash salts. After being used for this fresh lot of wool, this solution is run off for treatment to recover the potash, whilst the wool is again extracted with a second quantity of water which is less charged with salts. This process is continued for several baths, in the last of which the wool is treated with clean water which removes nearly all the remaining potash. The final result is that raw wool is entering the process at one end, and after passing through a series of treatments with weaker and weaker liquors, finally emerges free from potash salts at the other end, whilst the current of clean water entering at this end passes in the reverse direction through the various baths, becoming stronger in potash in each bath until it is finally run off for treatment at the end where the raw wool enters. The amount of water required for

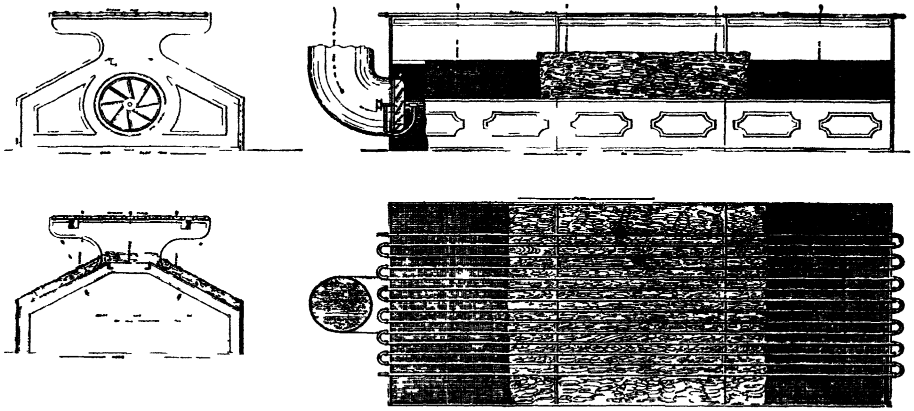


TABLE DRYER
(Wm Whiteley & Sons, Huddersfield)

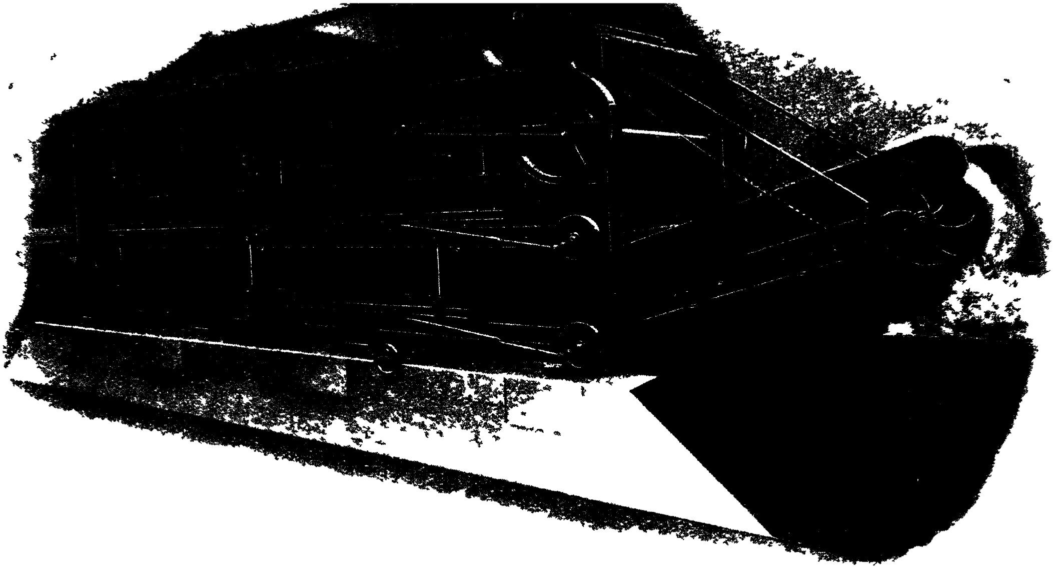
this process is very much less than would be required to extract the potash in a single bath, so that its evaporation is much less costly.

The saturated liquor is allowed to settle to deposit the heavy dirt and then evaporated to dryness and the residue heated to burn off as much organic matter as possible. The dirty mass of impure carbonate of potash obtained can be purified by dissolving it in water and allowing the salt to crystallize.

The process is only worth carrying out in cases where the output of scoured wool is very large.

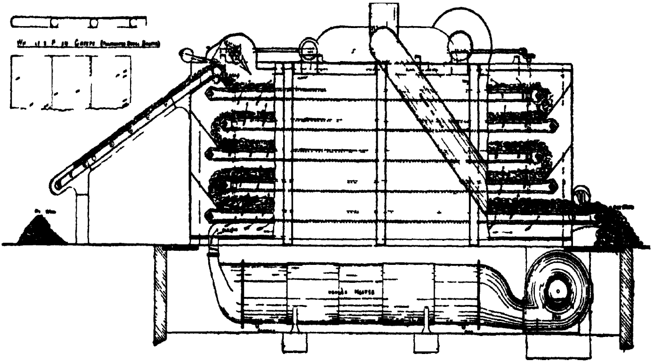
Wool Drying. If the scoured wool is to be dyed immediately or to undergo the process known as carbonizing, which will be referred to later, it is unnecessary to dry it, the bulk of the water having been squeezed out in the nip of the scouring machine. Very fine wools need little drying if they are to pass through the carding process but in most other cases the wool must be thoroughly dried.

One of the simplest methods of doing this is to spread the wool in a layer about 4 in. deep on wire netting and to blow a current of hot air through it. This is called a table dryer. The air is heated by means of steam pipes and blown through the wool by means of a fan. In the table dryer illustrated (Wm. Whiteley & Sons) the heating pipes are placed above the wool and the heated air is sucked downwards through the wool by a powerful fan which is placed beneath the table at one end. The drawback to this method is the labour entailed in spreading the wool on the table and removing it when dry, and also in turning it over during the process which is necessary to obtain even drying, and another objection is the large floor space required. The other method is to use a machine dryer. This has the advantage that it is continuous in action instead of being intermittent like



LOOSE WOOL DRYING MACHINE
(Petrie & McNaught)

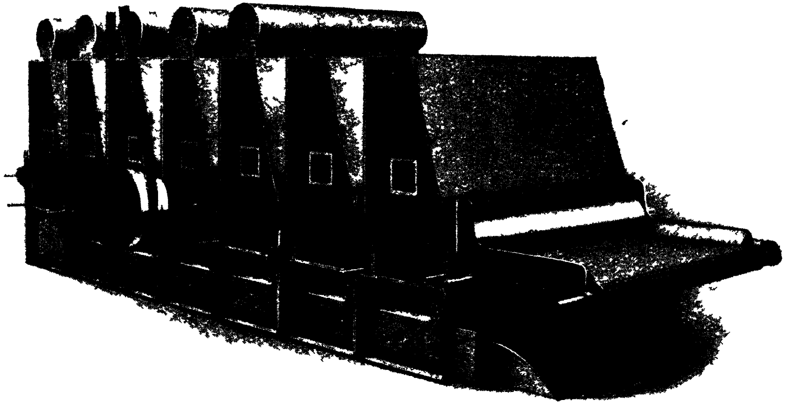
the table dryer and also takes up much less floor space. As usually constructed, these machine dryers consist of a closed chamber through which a current of hot air is circulated whilst the wool to be dried is passed through by means of travelling bands or other mechanism in the opposite direction to the current of hot air. Some of these machines will dry as much as 800 lb. of wool per hour. The temperature should not exceed 100° F. as otherwise the fibre is liable to be injured.



LOOSE WOOL DRYING MACHINE
(Wm. Whiteley & Sons, Huddersfield)

The illustration shows a novel drying machine constructed by McNaught of Rochdale

It consists of a number of similar vertical sections placed next to one another. The wool is fed into the first of these through a pair of rollers and is immediately met by a blast of warm air which blows the wool upwards as it is gradually released from the grip of the feeding rollers, removing a portion of the moisture and also dust, etc., which pass away with the air through perforations in the top of the section. As soon as the wool gets



WOOL DRYING MACHINE
(McNaught, Rochdale)

beyond the action of the air blast it falls on to a second pair of rollers which carry it onwards into a second section, where the drying process is repeated, and so on through each section.

The drying is stated to take from 1 to 3 minutes and the machine can dry from 350 to 1,000 lb. of wool per hour, according to the class of wool and the amount of moisture present. The machine is very compact and requires little floor space.

CHAPTER X

WOOL SCOURING (*Cont.*)

Scouring of Wool in other Stages of Manufacture. In the case of cotton the cleansing and scouring operations can be carried out at any stage in the manufacture, but owing to the great amount of impurity in raw wool the latter fibre is always first scoured in the loose condition. It would be quite impossible to carry out the various combing and spinning processes with a material containing, in some cases, as much as 80 per cent of its weight of grease and dirt of different kinds.

After passing through the scouring process the loose wool is in a fairly clean condition, but unfortunately, during its manufacture into yarn, the wool usually requires to be again oiled in order to facilitate the various combing and spinning operations.

The individual wool fibres are covered with minute scales which have one edge projecting slightly so that the fibres are not perfectly smooth but have a more or less serrated structure. Owing to this, the individual fibres tend to catch in one another, so preventing the free sliding of the fibres over each other during the combing and spinning processes. If the wool is oiled this tendency to entanglement is much diminished owing to the lubricating action of the oil.

Animal, vegetable and mineral oils are used for this purpose, either alone or mixed together, but the particular one chosen has a considerable influence on the later operations.

Whatever the oil used, it must be removed before the yarn or cloth into which the wool is being manufactured can be satisfactorily dyed or finished. If a vegetable or animal oil has been employed it can usually be easily removed by a scouring process with soap or alkali, but if a mineral oil is present its removal is much more difficult as it is unaffected by alkalies and can often be only partially removed as an emulsion with soap solutions.

The amount of oil present varies very much, but is usually greatest in yarns made from carded wools.

The yarn is scoured in soap solutions to which a little soda is frequently added in the case of very greasy wool. The machinery needed is of the simplest description and frequently consists of rectangular wooden vats containing the scouring solution which can be heated to the desired temperature by means of a closed steam coil. The hanks of yarn are placed on sticks, which lie across the vats so that the greater part of each hank is immersed in the liquor, and are turned several times by hand so that all parts of the hank receive an equal treatment. As in loose wool scouring, the temperature of the liquor must not be too high or the wool will be injured. After scouring, the yarn is taken out, drained and well washed with water on a special washing machine.

Yarn is sometimes scoured in machines constructed on a similar principle to the loose wool scouring machines previously described, being passed mechanically through two or more soap baths.

In the machine illustrated each wash bowl is fitted with two endless bands of lattice work which carry the hanks between them through the liquor and deliver them to the squeezing rollers, from which they pass on to the next bowl where the same process is repeated.

The same method of conveyance is sometimes employed in order to carry the yarn through a hot air drying machine as shown in the annexed illustration.

YARN WASHING MACHINE
(Petrie & McNaught)

Many yarns, especially tightly twisted ones, are very liable to curl or cockle up when wetted. To obviate this, use is made of the fact that the wool fibre becomes very plastic under the influence of heat, and if stretched whilst hot and allowed to cool in the stretched condition seems to lose its curling properties.

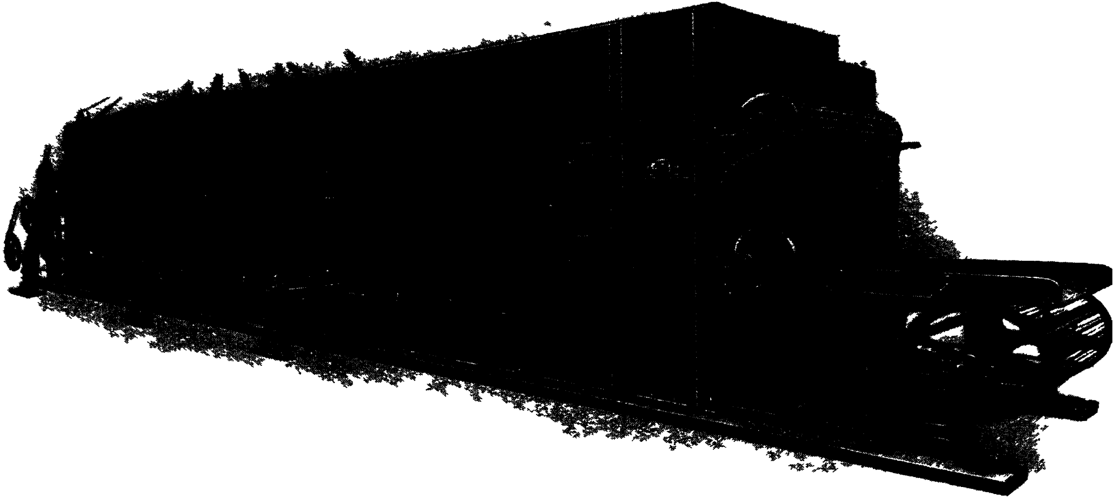
This operation is usually carried out before the scouring. The yarn, tied up in bundles, is steeped in boiling water for some time or else the hanks of yarn are tightly stretched on a metal frame and the whole immersed in boiling water. In either case the yarn seems to have taken a permanent *set* and to have lost its tendency to curl up on further wetting in the subsequent scouring or dyeing.

Piece Goods. If the yarn is to be woven into cloth which is to remain white or to be dyed in a plain colour it is unnecessary to scour it before weaving. As is the case with cotton goods the warp yarns often require to be sized or dressed in order that they may stand the strain of the weaving process. Formerly the animal fibres were usually sized with animal sizes and the vegetable yarns with vegetable ones; glue being the basis of the animal size and some kind of starchy matter the basis of the vegetable size.

At the present day, owing to questions of expense, vegetable sizes are largely used for both cotton and wool.

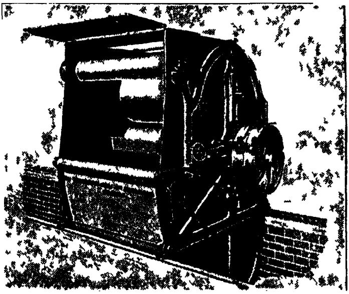
Whichever size be employed, the bundle of warp threads is passed through the mixture, well squeezed and then dried. The result is that the woven material contains all the impurities originally present in the yarn together with any added size, and all these should be removed before dyeing or finishing in order to obtain the best results.

The scouring of piece goods is usually carried out in a



“BRATTICE’ YARN DRYING MACHINE
(Petrie & McNaught)

special washing machine known as a *Dolly*. This consists essentially of a large vat to hold the *sud* over which are placed two large wooden rollers or *bowls*. The lower roller is driven by power whilst the upper one is revolved by the friction of the lower one, on which it rests. Several pieces of cloth are sewn together end to end and passed between the *nip* of the rollers, the extreme ends being then joined so that the cloth can run as an endless band. The scouring liquor is placed in the vat and heated to the required temperature, and on starting the machine the band of cloth passes continuously through the scouring liquor and the nip of the rollers. As a rule, no attempt is made to keep the cloth in the open width so that it takes the form of a more or less twisted rope. The upper roller runs in slotted bearings so that it can rise and fall according to the thickness of the cloth which is passing through and squeezes the soap liquor out of the cloth along with the dirt. In some types of machine a small trough is placed immediately below the rollers in order to catch the very



" DOLLY " WASHING MACHINE
(Wm Whiteley & Sons, Huddersfield)

dirty liquor which runs out in the earlier stages and prevent it fouling the liquor in the main vat. When most of the dirt has been removed the expressed liquor can be allowed to run directly into the tank. After scouring, the pieces are well rinsed with water in order to remove any remaining soap.

Some piece goods which are liable to cockle up in the scouring liquor are treated in special machines which keep the cloth tightly stretched in the open width.

Wool Scouring with Volatile Solvents. Although the wool grease is insoluble in water it can be dissolved in various organic solvents such as petrol or benzine and many attempts have been made to remove the grease in this manner by a process similar to that employed in dry cleaning.

The wool perspiration and most of the extraneous dirt are not removed by treatment with the solvent and require a subsequent wash with water for their removal.

Owing to the fact that this process obviates treatment of the wool with hot alkaline solutions, there is much less risk of injury to the fibre, and another advantage lies in the fact that the valuable wool grease can be recovered by evaporating off the solvent.

In practice, however, great difficulties appear to have been met with in carrying out this process, and it is only in quite recent years that these have been sufficiently overcome to allow of its use on the large scale.

The chief difficulty has been the dangerously inflammable character of the solvents employed, which has been the cause of serious fires. In one method, which has been used to a considerable extent, the raw wool is packed in closed vessels and hot air passed through to remove moisture which would interfere with the action of the solvent. The air having been sucked out by means of a vacuum pump, the solvent is forced through the wool under the pressure of an indifferent gas, such as carbon dioxide, which will not support combustion. The solvent is passed through the vessels on the counter current system so that the wool is treated with solvent of gradually increasing purity. When the wool has been cleaned from all the wool fat the stream of solvent is shut off and any solvent remaining in the wool is removed by passing a current of warm carbonic acid gas through the material.

The wool perspiration and the remaining dirt are then removed by washing the wool with water.

The solvent is distilled off from the fat and can be used again, whilst the fat has a very considerable commercial value.

Owing to the fact that the process is carried out in an atmosphere of an indifferent gas there is practically no risk of fire.

Recovery of By-products from Wool-Scouring Liquors. The waste liquors from the wool-scouring tanks were in former days run to waste into the nearest stream, but as the scale of wool manufacture increased the volume of these effluents became so large that the streams were seriously contaminated owing to the mass of greasy and other impurities present in the liquors, and finally legal steps were taken to compel the manufacturers to diminish this nuisance by submitting the liquors to, at any rate, a partial purification before running them into the streams.

At first this was looked upon as an unavoidable expense but it was soon found that, with proper treatment, these waste liquors could be made a source of revenue instead of expense, and at the present day most large wool-scouring works actually make a profit out of the purification of their waste liquors.

The composition of the liquors varies very much according to the quality of the wool which is being scoured and the particular process employed. They contain, of course, all the soap and alkali added to the water, together with the wool fat and wool perspiration removed from the wool, wool fibres and dirt of various kinds.

The wool perspiration consists chiefly of potash salts, and if only potash soaps and potash alkali have been used for the scouring it frequently pays to recover the potash from the liquors as it is a very valuable product, especially at the present time.

Of recent years, however, these potash soaps and salts have been largely replaced in scouring by the much cheaper soda compounds so that the potash salts from the wool are mixed with a large proportion of soda salts from which they cannot be separated by any practical method.

In places where the wool is given a preliminary steep in plain water, as previously described, this difficulty does not arise and the potash salts can be recovered from the steeping water by simply evaporating the latter and heating the residue to burn off organic matter.

In most works all that is attempted is to recover the wool grease and the fatty acids from the soap which has been used.

The usual method is to run the liquors into large tanks so that heavy impurities such as sand can settle to the bottom, and then to add sufficient sulphuric acid to the clarified liquor to decompose the soap and combine with all the alkali present.

The fatty acids from the soap usually rise to the top of the liquid along with the wool fat and form a thick oily layer or *magma*, which is removed, allowed to drain, and then wrapped in cloths and hot-pressed or passed through a heated filter press. A large proportion of the oily matter present is squeezed out and run into barrels in which it sets to a solid mass on cooling, whilst the residue in the press, which still contains some grease, is sometimes extracted with organic solvents, such as benzine, to recover this.

The solid grease extracted by hot pressing is sometimes known as *Yorkshire grease* and is disposed of to the grease merchants, who usually purify it by distillation to obtain a liquid product known as *distilled wool olein*, which is used for oiling wool, and *wool stearine*, which is employed as a cheap lubricating grease or for the manufacture of cheap soaps, etc.

The process above described gives a mixed product containing not only the wool grease but also the fatty acids from the soap used for scouring. Several processes are in use which aim at the separation of the wool fat by itself as it is a more valuable product than the mixture usually obtained.

In the Smith-Leach process the waste liquors are passed through large settling tanks to remove most of the sand and other heavy impurities and then evaporated down to about a tenth of their bulk. The hot liquor is then run into a centrifugal machine which is revolved at a high speed. The sand and other heavy matter collects against the outer side of the revolving vessel whilst the light wool grease remains near the centre and is removed continuously through a skimming pipe. The soap solution, containing the potash salts from the wool together with any alkali added to the baths, takes an intermediate position and runs off through another pipe. The wool grease is simply boiled with water and is then obtained in a very pure condition, whilst the soapy liquor, now free from grease, is evaporated further to obtain the potash salts. In a more recent method, described by E. V. Chambers, the waste liquors are run directly, without any previous evaporation, through a centrifugal machine which effects a partial separation, and the soapy liquor is run back to the scouring plant and used again ; this process being repeated until the liquor becomes too strong in salts, when it is worked up for the recovery of the potash. This method is stated to effect a very considerable saving of soap. Of course, if soda compounds have been added during the scouring, the potash obtained will be mixed with soda, but this mixture can still be employed for manurial purposes.

The best wool grease can be worked up into *Lanoline*, which is largely employed in medicine, whilst the inferior products can be used for oiling leather, lubrication, etc.

It is stated that on the average 1,000 gallons of waste liquor will contain 80 lb. of wool grease, so that in a works producing many thousands of gallons per week the value of the products is very considerable. In some cases the profits on grease recovery are said to amount to many thousands of pounds per annum.

The waste liquors contain a considerable quantity of wool fibres which can be recovered by a special screening arrangement and add to the profit of working.

Carbonizing. Some wools, especially foreign ones, contain a large amount of vegetable matter which they have picked up from the herbage of the feeding grounds. Much of this vegetable matter consists of the prickly seed-pods of various plants and these become tightly embedded in the fleeces. Besides these *burrs*, as they are termed, other vegetable matter is frequently present, e.g. fibres from the sacks used to carry the wool.

The scouring operation removes some of this and a further amount is extracted during the various processes through which the wool passes in its manufacture into yarn, but a certain proportion usually remains in the finished material.

If wool containing these particles of vegetable matter be dyed, the latter are, in most cases, left practically undyed, as they have little attraction for most wool dyes, with the result that they show up as light specks in the dyed material and depreciate its value. If the cloth contains only a few of these *burls*, as they are termed, they are sometimes removed by hand, but if they are very numerous this becomes practically impossible and a chemical method is usually employed.

This method is called *carbonizing*, and depends on the fact that vegetable matter, which consists mainly of cellulose, is very easily attacked and disintegrated by treatment with mineral acids, especially on heating, whilst the wool is little affected.

The process is performed either directly after the scouring of the loose material or else before or after the dyeing of the woven cloth. The cloth is steeped for some time in a dilute solution of sulphuric acid in water, well squeezed, dried at a moderate temperature, and then heated to a temperature of about 180° F. in a special chamber called a carbonizing oven or stove. The heat drives off the excess of water so that the sulphuric acid becomes concentrated on the material and acts with destructive effect on the vegetable matter present, converting it into a very friable mass which can be easily shaken or beaten out of the material by mechanical means. The woollen cloth is then well washed with water to remove the acid, the last traces of which are frequently got rid of by adding a little soda to the rinsing water.

In place of sulphuric acid other acid substances such as hydrochloric acid or aluminium chloride are sometimes employed. If the material is to be carbonized after dyeing a dye must be chosen which will withstand the acid treatment.

CHAPTER XI

WOOL BLEACHING

THE great bulk of the sheeps' wool which comes into the market is, after scouring, very light in colour, having usually a yellowish-white tinge. There are, however, a number of foreign wools imported which vary in colour from brown to black. These very dark wools are usually employed in their natural colour or else dyed in very dark shades as it is practically impossible to bleach them to a satisfactory white by any commercial process.

In the case of ordinary sheeps' wool it is usually unnecessary to bleach this if it is to be dyed in fairly full shades, but if very delicate shades are required, or the wool is wanted *white*, it is necessary to remove the yellowish tinge so far as possible.

For material which is to remain white this is sometimes effected by a process known as *white-dyeing* or *blueing*, which consists simply in applying a trace of a blue dye or pigment to the wool so as to counteract the yellowish tinge and give a white appearance. The trace of blue colour simply absorbs the yellow rays of light which would otherwise be reflected from the material. This is exactly the same in principle as the use of the *blue-bag* in ordinary domestic washing.

The disadvantage of this method is that the blue colour is usually not permanent, but is soon removed when the material is washed, so that the yellow colour quickly returns. Better results are obtained by converting the yellow colouring matters present into a colourless form by chemical treatment. This can be done either by using a *reducing* chemical such as sulphur dioxide or an oxidizing one such as hydrogen peroxide. In the former case the destruction of the yellow colour is not complete as it is only converted into a colourless compound which gradually changes back into the original yellow form on exposure to the air or washing. This can often be noticed in the case of materials such as blankets which, when new, are often nearly a pure white, but after a few months use and washing gradually become more and more yellow.

The oxidation method has the great advantage that the colour is permanently destroyed and cannot be regenerated, but, on the other hand, it is much more expensive than the reduction method, and is therefore restricted in its use to the better class materials.

The commonest method of wool bleaching, and one which has been in use for several hundred years, is to submit the wool to the action of the fumes produced by burning sulphur in the air. These fumes really consist of a compound of sulphur with the oxygen of the air, which is known chemically as sulphur dioxide, and is the most important reducing bleach for animal fibres. It can either be employed in the gaseous form, " the gas bleach," or else as a solution in water, " the liquid bleach," the first method being the more usual.

Sulphur Bleach. This is carried out by exposing the wool to the action of sulphur dioxide gas in closed chambers which are known as *stoves*, the process being frequently called *stoving* or *sulphuring*.

Wool is usually bleached in the form of yarn or piece goods but can also be done in the loose condition. The material is first thoroughly scoured in order to remove all greasy impurities and then, as the white obtained by this method is usually not perfect, the scoured material is often worked for a short time in a tepid soap bath containing a small quantity of some suitable blue or violet colour, for blueing purposes. The material is then lifted, hydro-extracted or squeezed as evenly as possible and placed, without further drying, in the sulphur stove.

This stove is a closed chamber constructed in various sizes according to the size of output required and lined with wood, brick, glass or other material which will resist the corrosive action of the gas. Great care must be taken to exclude any metal nails, etc., which would be attacked by the gas and be liable to cause stains on the goods. When the stove is charged with wool it is closed and a quantity of sulphur amounting to about 7 per cent on the weight of the wool is ignited, either in the stove itself or else in an adjoining chamber, so that the sulphur dioxide formed by the burning sulphur fills the stove and acts on the wool. The stove is kept closed for several hours or even overnight, according to the degree of bleaching required, and the remaining fumes are then removed by opening a flue and passing a current of air through the stove.

The wool is then removed and hung in the air to remove as much adhering gas as possible and finally dried. If this process be used for loose material the latter is usually spread on trays which are placed in the stove. Hanks of yarn are hung on wooden rods whilst piece goods are either suspended in a similar manner or else bleached by a continuous process, the stove being fitted with a system of rollers over which the cloth passes in the open width, entering and leaving the stove through a narrow slit in the side.

If a single treatment in the stove does not give a good enough white the process is repeated one or more times.

The sulphur dioxide adheres very obstinately to the wool and if bleached yarn be woven with dyed yarn the latter may be partially bleached by the gas remaining in the white wool.

This remaining gas can be destroyed by treating the stoved wool with a weak solution of hydrogen peroxide, which converts any sulphur dioxide present into sulphuric acid, which does not injure colours as it is removed by washing with water.

When dyeing some very brilliant shades on wool the stoving is often carried out after dyeing, but the dyes employed must stand the bleaching operation.

Liquid Bleach. This method, which is much less used than the above, consists in soaking the wool for some hours in a solution of sulphur dioxide gas in water.

The solution can be prepared from the liquefied gas, which is now an article of commerce, or else by making up the bath with bisulphite of soda and adding enough acid to liberate the gas.

Oxidation Bleaches. The second method of bleaching wool is by means of oxidizing agents. Unfortunately, it is impossible to use the oxidizing bleach so important for vegetable fibres, namely bleaching powder, owing to the fact that wool is very strongly attacked by chlorine and the hypochlorites which, even if used weak, harden the fibre and turn it yellow. Strong solutions of these substances convert the wool into a sticky yellow mass.

The most important oxidizing bleach for animal fibres is hydrogen peroxide, which has no injurious action on the fibre when properly applied. In former days this was supplied to the bleacher as weak solution in water, but its bad keeping qualities and the expense of carriage of such a bulky material militated against its general use.

The actual bleaching process with this substance is very simple. A vat, best constructed of wood, is charged with the hydrogen peroxide solution diluted with a suitable quantity of water, according to the intensity of bleaching required, and a little ammonia added so as to make the solution slightly alkaline, which improves its bleaching action. The raw wool is then entered into the cold bath and the temperature gradually raised to about 120° F. The bleaching action is completed in a few hours, after which the wool is lifted, rinsed with water and dried.

At the present date, the bleacher prepares the hydrogen peroxide himself as required, from sodium peroxide (*q.v.*). The bath is prepared with water and sufficient sulphuric acid and the sodium peroxide powder carefully stirred in. The acid present converts the sodium peroxide into hydrogen peroxide and, after the addition of a little ammmonia to neutralize any excess of acid, the bleaching is carried out as described above. The great advantage of the oxidizing bleaches is that the colour of the wool is permanently destroyed and does not return after a time, as is the case with wool bleached by reducing agents; on the other hand, as already mentioned, the oxidation method is considerably more expensive than the reduction one and is therefore largely confined to better qualities of material.

Several other bleaching agents are used to a small extent, but the main bulk of wool is bleached by one of the above mentioned methods.

CHAPTER XII

SILK SCOURING AND BLEACHING

Raw silk as it comes into the market is very different in appearance to the brilliant lustrous fibre of the shops. It is a stiff, harsh fibre with only a dull lustre and varies in colour from an almost pure white to a bright yellow with ordinary cultivated silks, whilst the so-called *wild silks*, such as Tussah, which are obtained from wild silkworms instead of from the ordinary cultivated variety, vary in colour from a pale buff to a brown.

The stiff handle and dull lustre of the raw material are due to the coating of silk-gum with which the real silk fibres are covered, and in order to develop the full brilliancy and lustre of the fibre this gummy layer must be removed.

The best quality of silk is that which has been reeled directly from the cocoons and comes into the market in the hank form. It consists of a long continuous thread which has been made by twisting the single fibres from several cocoons together. This product is known as *Net* or *Reeled Silk.*

The shorter, broken fibres are carded and spun into *Spun Silk.* As already mentioned, the silk-gum is soluble in soap solutions, and this fact is taken advantage of in the purification of the fibre. Raw silk contains from 20 to 30 per cent of gum so that its complete removal causes a serious loss in weight and various processes are in use to develop as much lustre as possible without removing all the gum.

The raw silk is first submitted to the *de-gumming* or *boiling-off* process.

The hanks of silk are hung on smooth wooden sticks and suspended in a soap solution containing about 30 per cent of a good olive oil soap, calculated on the weight of the silk. The hanks are carefully worked in this solution at a temperature a little below the boil for from 1 to 2 hours. The silk-gum gradually softens and swells up and then dissolves in the soap liquor, so that the two threads of the original double fibres separate and the silk fibres begin to appear in their true brilliancy.

This process is sometimes effected in two or more successive soap baths, on the counter current system, so that the raw silk is first treated with a soap solution already partly saturated with gum and then passes into cleaner ones. The strong solution of silk-gum in the soapy liquor is known as boiled-off liquor and is largely used as an addition to the dye bath when dyeing the silk with artificial dyestuffs, as it is said to improve the evenness of the dyeings and the handle or feel of the silk.

The boiled-off silk is rinsed in water with the addition of a little soda and is then ready for use if the silk is to be dyed in dark shades.

If a completely boiled-off silk is required the ungummed silk is placed in linen bags, and the latter are actually boiled for some time in a weaker soap solution than was used previously.

To obtain a pure white silk the boiled-off material is bleached by similar processes to those employed for wool. The hanks of silk yarn can be simply hung in a sulphur stove in the usual manner, or the hydrogen peroxide method can be used which gives more permanent results.

Tussah silk is much more difficult to bleach than ordinary silk. It is sometimes boiled in a weak soda solution, rinsed with water and soured with dilute hydrochloric acid, being finally again rinsed and bleached if necessary

The boiling off process described above causes a very serious loss of weight, amounting to from 20 to 30 per cent reckoned on the raw silk This, of course, makes the product very expensive and therefore another process is frequently employed which gives a fairly soft product, suitable for dyeing, without this serious loss in weight.

The silk thus obtained is known as Souple silk The raw silk is worked for a short time, at a quite moderate temperature in a fairly weak soap solution, and is then (if yellow in colour) bleached with a weak solution of *aqua regia*, which is a mixture of nitric and hydrochloric acids.

The silk is well washed with water and is then stoved in a sulphur stove, being finally treated with a solution of cream of tartar and washed

In this process much less silk-gum is removed, so that the loss of weight is sometimes only about half that suffered in the full boiling-off process

CHAPTER XIII

THE BLEACHING TRADE

IN early times, when spinning and weaving were home industries and the women of the household manufactured the necessary clothing for their families, often from home-grown wool, the primitive cleansing or bleaching operations in use were naturally carried out at home also. As the industry increased, however, and became more specialized, separate bleaching establishments were set up to which the manufacturers sent their materials for bleaching.

The chief seat of the bleaching industry in this country is naturally in those districts where the textile trade has had its greatest development, namely, in Yorkshire and Lancashire. So far as linen bleaching is concerned, the Belfast district holds the first place.

At the present date the bleaching of cotton and linen for " white " goods is usually combined with the finishing operations and is carried on as a more or less independent branch of the textile trade, although many of the larger firms manufacture and bleach their own material.

The scouring and bleaching of materials which are to be dyed or printed is most often done by the dyers or printers themselves immediately before use. In the case of loose wool, the scouring is usually carried out by the comber.

The magnitude of the bleaching industry in this country may be shown by the following figures which have been taken from the 1907 Census of Production. a

The total output as there stated includes—

COTTON PIECE GOODS

Bleached but not dyed or printed	2,192,504,000 yds.
Dyed but not printed	1,121,778,000 yds.
Printed	1,326,061,000 yds.

As a considerable proportion of the dyed cotton will have been previously cleansed or bleached, the above figures show that approximately 4,000 million yards of cotton cloth must have been bleached to some extent.

The cotton yarn bleached or dyed, etc., amounted to 189,626,000 lb. in weight, whilst the figures for linen yarn are 141,178,000 lb. and for linen cloth, 133,996,000 yards.

In the case of wool the actual bleaching operation is less important than with cotton and linen, but, on the other hand, practically all the wool used has to be scoured before manufacture.

Figures are not available of the actual quantity bleached, but the weight of raw wool consumed, in this country alone, is calculated at about 600,000,000 lb. per annum.

The few figures quoted above will serve to give the reader some idea of the magnitude and importance of the industry which the author has endeavoured to describe in the previous chapters.

APPENDIX

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